Geological Survey of the State of New York.

PALÆONTOLOGY:

VOLUME VIII.

AN INTRODUCTION TO THE STUDY

OF THE

GENERA

OF

PALÆOZOIC BRACHIOPODA.

PART I.

BY

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ASSISTED BY

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DEDICATION.

To His Excellency

ROSWELL P. FLOWER,

Governor of the State of New York:

SIR:

I have the honor to present to your Excellency a new volume of the NATURAL HISTORY OF THE STATE OF NEW YORK, forming a continuation of the work on the Palæontology of the State.

This volume together with one other, already far advanced in its preparation, will complete the work upon the revision of the genera of the PALÆOZOIC BRACHIOPODA. The investigation, begun many years ago, and for a long time suspended, was resumed only in 1888, and while in the outset laboring under many disadvantages for want of adequate collections, the difficulties have been mainly overcome and the author is able to present the volume in a satisfactory form. The advance in our knowledge of this class of fossils during the past twenty-five years, and the later accumulation of material from various sources, for the illustration of the work, are the causes which have expanded the proposed Part ii of Volume IV of 1867 into two volumes, of which this is the first. The work has for its final object the bringing together, under one title, a summary and revision of all the genera of this class of fossils known in the rocks of New York and the adjacent States, to the Coal Measures inclusive. This will also serve as a revision of the genera and species already described in Volumes I to IV of the Palæontology of New York, published during the interval from 1847 to 1867.

The publication of the volume has been greatly delayed by causes beyond the control of the author, but the Act of the Legislature, Chapter 170 of the

Laws of 1892, has made provision for the completion of this and the subsequent volume. The present volume is the first fruit of that act, and I trust that its publication may give you personal satisfaction, and that it may commend itself to the student of geological science and prove worthy of a place among the great series of works comprising the Natural History of the State of New York.

I have the honor to remain,

With great respect,

Your obedient Servant,

JAMES HALL,

State Geologist.

ALBANY, N. Y., *May* 18*th*, 1892.

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PREFACE.

The completion of the present volume is a partial fulfillment of a promise made at the close of Volume IV of the Palæontology of New York, in 1867. The work is presented to the student with a hope that it may prove a useful contribution to science and a helpful guide in the study of that most abundant and most important class of Palæozoic fossils, the Brachiopoda. Originally intended to form a supplementary part of Volume IV, the subject has expanded to such an extent that two volumes will be required to present the results with a reasonable degree of completeness; and even with this addition some very important matter, as the microscopic shell structure, originally intended for the work, will have to be omitted from these volumes.

The study of the Brachiopoda made necessary in the preparation of Volumes III and IV, and more especially in the latter, had shown the necessity of subdividing many of the older recognized genera, which had become the receptacle for forms having external similarity to the typical members of the several groups, but possessing quite dissimilar internal features. The natural disinclination to propose new generic terms for members of a class of fossils which had been so widely and thoroughly studied in Europe, operated as a restriction in the erection of new names However it became necessary to describe in those volumes and in cotemporary papers some thirty-one new generic forms and to suggest the necessity for farther separation among other heterogeneous assemblages. These studies, made with fairly good collections, and ranging through the Silurian and Devonian faunas, could not fail to attract attention to the different external aspects and interior characters of forms known under the same generic terms, and considered as distributed through all the Palæozoic formations. Although the genera thus far proposed had not been based upon a recognition of their appearance and duration in geological time, yet the student could not fail to discover evidences

of organic change in this direction. While discussing certain generic and specific forms as characterizing known geological horizons or certain groups of strata, we had not yet taken into consideration the fact that modifications of organic types had been coincident with every change or progress in geological time. The great law of progress through long intervals had been everywhere recognized in geological science, but just how or in what manner these changes had supervened had rarely been shown in detail. Certain fossil genera have long since been recognized as Silurian, others as Devonian, and others as Carboniferous, but these are never entirely restricted to the formations which they are said to characterize. They have all doubtless been derived from some remote progenitor, and at certain horizons, or throughout certain formations have become so abundant and so fully developed, that they are said to characterize that stage or formation. The most abundant and extravagant forms among fossil organisms can usually be traced to some parent stock of more modest pretensions, and in their early appearance, represented by few individuals.

As stated, the studies of the Brachiopoda to the close of Volume IV of the Palæontology had shown the importance of some investigation which should deal directly with these questions. And moreover the science demanded the results of such an investigation in aid of its future progress.

The original conception and plan of the work which the author had proposed to himself was a very simple one, viz.: to select the earliest representative of a genus in any of the geological formations and to follow it through all its manifestations and modifications in geological time, to its final disappearance: or so far as these modifications should appear in the Palæozoic rocks, to which he had limited his research.* With the knowledge then possessed and with the collections at his disposal he had supposed that the result of such an investigation could be embraced in a supplementary part to Volume IV, and under this title the work was announced. This study was commenced very soon after the publication of that volume and its general plan

*The difficulty of procuring sufficiently abundant and characteristic collections of the later formations was in itself a sufficient barrier, and the scope of the work did not contemplate the discussion of Mesozoic and later genera, except in an incidental manner.

was carried out so far as the lithographing of about thirty plates, when the farther progress of the work was suspended, to be resumed only in the latter part of 1888.

In the meantime the duties of the author had separated him almost entirely from this work, and owing to changes, over which he had no control, in the organization and management of the State Museum, the collections which he had planned to make for use in its preparation had not been made. The progress in our current knowledge of the subject, and that recorded in the publication of volumes and miscellaneous papers during more than twenty years had been enormous, and the undertaking which had been deemed feasible in 1867, seemed almost beyond attainment in 1888. The work was resumed however, with no other collections immediately available for use, than those upon which it had been commenced. In the original plan four plates were left for the illustration of the Inarticulata; the present volume furnishes ten additional plates, and the illustrations of these forms may be regarded as fairly complete, according to our present knowledge.

The plates which were lithographed at the commencement of the work are designated on the upper left-hand margin as "Volume IV, Part II." Those lithographed since 1888 are designated as Volume VIII, and while the illustrations of the first named plates are not always arranged as would have been done with later knowledge and more abundant material, it is hoped that the intercalation of the new plates may not seriously interfere with the proper connection and continuity of the work, or with the facility of reference so important to the student. Although the final numbering is XX, the actual number of plates in the volume is forty-two

The printing of this volume had been completed to the end of the Inarticulata, page 183, in March, 1890, when farther progress was suspended, from causes over which the author had no control. The printing was resumed in the autumn of 1890, and the book was in type to page 304 in February, 1891, when its progress was again suspended to be resumed only in April, 1892. This delay in publication, which has not in any way been due to the author, requires an apology to the scientific public; and those authors who may have

published papers relating to the Brachiopoda, during 1890 or 1891 which could not be cited in this volume, will here find the explanation.

At the time this work was commenced the earliest known articulate Brachiopod had been described under the name of ORTHIS, and without having the knowledge or means to verify or disprove the character of this fossil, the genus ORTHIS was adopted for the basis of discussion. Had these older forms been better known, the order of the work might have been somewhat modified. The other associated and succeeding genera have been taken up and treated after the same idea as in ORTHIS: limiting the discussion to those which seem to be a natural result of the modification of certain essential organic features characterizing the earliest forms of the orthoid type.

Following this order and method we pass through all the *ORTHIDÆ*, the strophemenoid and streptorhynchoid forms in their varied aspect and modification, and through the leptænoid forms to CHONETES and the *PRODUCTIDÆ* proper, with which the series seems naturally to end.

All the spire-bearing forms, all the *RHYNCHONELLIDÆ* and *PENTAMERIDÆ* as well as the terebratuloid forms have been left out of consideration in the present volume, believing that a more natural and useful classification will be found in the present adopted order and arrangement of the genera. Chapters upon the classification and broader relations of the genera are given at the conclusion of the two principal divisions of the work. The succeeding part ii of volume VIII will embrace the discussion of the genera under the several groups just mentioned, and they will be treated essentially in the same manner as in the present volume. The work on the second part is already far advanced; a large amount of material has been accumulated for study; thirty-six plates have been lithographed, a considerable number of drawings have been made and a large amount of manuscript has been prepared.

During the interval of more than twenty years from its commencement, great progress has been made in the study of both genera and species of the Brachiopoda. The late THOMAS DAVIDSON, LL. D., of Brighton, whose life had been devoted to the study of these organisms, living and extinct, made important contributions to our knowledge up to the time of his death in 1885. Essays

toward the structure and classification of the genera were made by ZITTEL, ŒHLERT and WAAGEN, and communications of no little importance relating to structural characters of genera and species, appeared from all quarters of the scientific world.

The multiplicity of these communications is indicated in part by the bibliographic tables presented in this volume; they also show the wide-spread interest in the Brachiopoda, not only among students of biology, in their structure, morphology and taxonomy, but among geologists, in their value as stratigraphical indices. American students have heretofore labored under a disadvantage in the irregular diffusion of the literature of the Brachiopoda. Much of the European literature is inaccessible except to those working in the vicinity of extensive libraries; the American literature is so scattered through scientific periodicals, proceedings of various societies, etc., as to be frequently inaccessible. Furthermore, while the more general treatises of ZITTEL and ŒHLERT may be in the hands of many, the greatest of all works upon the subject, that of THOMAS DAVIDSON, is beyond the reach of but a very few.

With this volume, therefore, is presented, especially to American students, the first part of "An Introduction to the Study of the Genera of the Palæozoic Brachiopoda," a work not conceived upon the plan of any of its predecessors, but designed to set before the student the present condition of our knowledge of these genera, with such discussions and illustration as will serve most clearly to indicate what progress has been made in our knowledge of these organisms and in what directions much still remains to be done.

In the preparation of this work every effort has been made to bring under close and careful scrutiny all obtainable material representing the Brachiopoda. The collections of no single institution or individual could furnish the specimens requisite for this undertaking, and recourse has been had to all sources of material within reach. The collections of private individuals as well as of public institutions have been placed at the disposal of the work, and but for such aid it could not have been presented in a creditable form.

My acknowledgments are especially due to Sir WILLIAM DAWSON, Principal of McGill University, Montreal, Canada, for specimens and valuable informa-

tion: to Mr. G. F. Matthew, of St. John, N. B., for the use of fossils of the St. John group, and for valuable information concerning them; to Hon. A. R. C. Selwyn, Director, and to Mr. J. F. Whiteaves, Palæontologist, for the use of many typical specimens from the Museum of the Geological Survey of Canada. Also to Mr. W. R. Billings, of the Department of Public Works, Ottawa, Canada, and Mr. H. M. Ami, of the Geological Survey.

From Mr. Thomas A. Greene, of Milwaukee, Wisconsin, I have received most important material from the Niagara group of Wisconsin; from Dr. Josua Lindahl, Curator, and from the Trustees of the Illinois Museum of Natural History, the free use of its collections; from Prof. C. L. Herrick, of Chicago, the use of his typical collection of the Waverly group; from Prof. James M. Safford, of Nashville, Tenn., interesting material from his collections which have been utilized in the illustration of the *Orthidæ*. To Prof. J. S. Newberry, I am indebted for the free use of his very interesting collections, especially of the Carboniferous fossils; to Prof. Edward Orton, for his liberality in permitting the free access to the collections of the Geological Survey of State of Ohio; to Prof. G. C. Broadhead, of the University of Missouri, for the use of many interesting forms of Carboniferous fossils; to Rev. John Bennett, of Kansas City, for the use of very interesting Coal Measure fossils, especially of the genera Derbya and Enteletes; to Prof. Samuel Calvin, of the University of Iowa, for his liberal aid toward the illustration of the Silurian and Devonian Brachiopoda of Iowa; to W. C. Egan, of Chicago, for the use of some interesting forms of Carboniferous fossils, and to Dr. C. Rominger for his liberal and intelligent contributions to our knowledge and means of illustration of the Brachiopoda, an obligation beginning as far back as 1863.

From the American Museum of Natural History, through Prof. R. P. Whitfield, specimens representing many genera and the types of many species have been received; from Prof. J. P. Lesley, State Geologist of Pennsylvania, a series of inarticulate Brachiopods from that State; from Mr. Charles D. Walcott the use of specimens and information concerning the same; from Prof. James R. Eaton, of William Jewell College, Missouri, during many years, the use of specimens and for much intelligent information; from Rev. H. Herzer, the

use of some interesting specimens of recent collection and information concerning certain horizons in the Lower Carboniferous strata, and also the abundant material of his earlier collection; from Prof. E. W. CLAYPOLE, the use of specimens, as well as information concerning the geological relations of certain species; from Pres. E. S. BRAINERD and Prof. H. M. SEELY, of Middlebury College, Vt., the use of specimens from the Calciferous horizon, which have since been donated to the State Museum; from Prof. GEO. H. PERKINS, of the University of Vermont, the use of specimens; from E. E. TELLER, of Milwaukee, Wis., and F. A. SAMPSON, of Sedalia, Mo., similar favors. Acknowledgments are further due to Mr. F. A. BLAIR, of Sedalia, Mo., and Dr. J. H. BRITTS, of Clinton, Mo., for the use of specimens and especially for a collection of Choteau limestone fossils from the former; also to W. H. R. LYKENS, S. J. HARE, F. W. McINTOSH, of Kansas City, for specimens of Coal Measure fossils; also to Prof. THOMAS B. STOWELL, of Cortland (now of Potsdam), N. Y., W. L. BROWNELL and D. S. CHATFIELD, of Syracuse, and E. B. KNAPP, of Skaneateles. To Prof. B. K. EMERSON, of Amherst, Mass.; to Dr. C. E. BEECHER, of New Haven, Conn.; and to E. O. ULRICH, of Newport, Ky., thanks are due for specimens and information; also to W. T. KNOTT, of Lebanon, and Mr. E. C. WENT, of Frankfort, Ky.; to Prof. WILLIAM LIBBEY, of Princeton, N. J., through MORITZ FISCHER; Prof. JOSEPH MOORE, of Earlham College, Richmond, Ind.; to Col. C. C. GRANT, an old and valued correspondent, and Mr. WILLIAM TURNBULL, of Hamilton, Ontario, and to Mr. B. E. WALKER, of Toronto, for specimens from the Niagara and Hudson River groups; to Professors OLIVER MARCY, of Evanston, Ill., EDWARD M. SHEPARD, of Springfield, Mo., W. H BARRIS, of Davenport, Ia., and S. S. GORBY, State Geologist of Indiana; to L. A. COX and D. G. ANDERSON, of Keokuk, Ia., for brachiopods of the Keokuk group, presented by them to the State Museum; to R. R. ROWLEY, of Curryville, Mo.; to Miss MARY E. HOLMES, of Rockford, VICTOR E. PHILLIPS, of Olney, and J. H. SOUTHWELL, of Rock Island, and to W. R. HEAD, H. H. HINDSHAW, and VICTOR C. ALDERSON, of Chicago, Illinois.

Among foreign friends and correspondents, my first acknowledgments are due to the late THOMAS DAVIDSON, of Brighton, England, for many years of personal

friendship and intimate correspondence relating to scientific questions, and especially to the Brachiopoda. The pages and illustration of this volume will bear testimony to the knowledge derived from this eminent source. Also to Dr. Th. Tschernyschew and Dr. Fr. Schmidt, of St. Petersburg, Russia; to Prof. E. Kayser, of Marburg, Germany; to Miss Agnes Crane, of Brighton, England; Dr. D. P. Œhlert, of Laval, and Prof. Charles Barrois, of Lille, France; to Dr. G. Lindström, of Stockholm, Sweden, and to Mr. John Young, of Glasgow, Scotland, acknowledgments are especially due.

The lithographic plates accompanying this work have been drawn on stone by Mr. Philip Ast, whose accurate and artistic execution of similar work is already known to the students of these volumes. The original drawings of the earlier plates were mostly made by Mr. R. P. Whitfield and the late Mr. F. B. Meek; the drawings for the later plates was begun by Mr. E. Emmons, whose services were subsequently supplemented by the skillful and beautiful work of Mr. George B. Simpson.

To Mr. Charles Schuchert, my private assistant, this volume owes much. His critical knowledge of the species of American Brachiopoda, and his familiarity with the literature pertaining to them, as well as his unequaled collection of fossil Brachiopoda, have all been placed at the disposal of the work with the devotion characteristic of the student. To him is due the fullness of the bibliographic tables, which afford virtually a complete summary of American literature upon these genera.

To Prof. John M. Clarke, Assistant Palæontologist, I am especially indebted for his faithful and appreciative devotion to the accomplishment of this undertaking. On the resumption of this work in 1888, Mr. Clarke was appointed my official assistant, and he entered at once into sympathy with my plan, and became an enthusiast in the study of the Brachiopoda. To him I am indebted for carrying out in its details, the spirit of my conception to a degree of completion which I had not anticipated.

JAMES HALL,

Albany, *May*, 1892. *State Geologist and Palæontologist.*

INTRODUCTION

TO THE

STUDY OF THE GENERA OF THE PALÆOZOIC BRACHIOPODA.

I.

BRACHIOPODA INARTICULATA.

Valves inarticulated; intestine terminating in an anus on one side of the body; shell substance largely phosphatic.

THE foregoing characters bring into association a well defined assemblage of these organisms, but, while generally applicable throughout the group in expressing the fundamental distinctions from the more abundantly developed BRACHIOPODA ARTICULATA, there often appear, in forms which cannot be separated from such association, tendencies to transgress these limitations in various directions. For example, articulation of the valves was approached, if not effected, in the linguloid BARROISELLA, in SPONDYLOBOLUS, and, perhaps also, in NEOBOLUS and TRIMERELLA. In CRANIA, according to the determination of JOUBIN,* the anus opens in the median line of the body; and in various genera, CRANIA, PHOLIDOPS, TRIMERELLA, etc., there is evidence that the substance of the shell was essentially, or altogether calcareous.

We have preferred to adopt for this division of the Brachiopods, Professor HUXLEY'S† term, INARTICULATA, which has the advantage of euphony and simplicity. Other writers have made use of terms with different significations, all

*See under genus CRANIA.

† An Introduction to the Classification of Animals, p. 116. 1869.

having precisely the same scope. Professor OWEN,* in 1858, proposed the term LYOPOMATA (λύω and πῶμα), essentially the Greek equivalent of INARTICULATA, and of BRONN'S† ECARDINES. The last named author also suggested the term PLEUROPYGIA, derived from the lateral position of the intestinal perforation; while KING'S term, TRETENTERATA,‡ indicates that the existence of an anus is to be regarded as the essential character.

The use of *Family* designations in this group would be attended by embarrassments so serious, that it has seemed preferable to avoid them altogether. The present state of our knowledge fully justifies this position.

GENUS LINGULA, BRUGUIÈRE. 1789.

PLATE I, FIGS. 1-34; AND PLATE IV K, FIGS. 5-13.

1789. *Lingula*,§ BRUGUIÈRE. Hist. Natur. des Vers Testacés.
1798. *Pharetra*, BOLTEN. Mus. Bolt.
1806. *Lingularius*, DUMÉRIL. Zoologie Analytique.
Lingula, of authors generally.

Glossina, PHILLIPS, 1848. Mem. Geol. Surv. Great Britain, vol. ii, pt. 2, p. 370.
Glottidia, DALL, 1870. American Journal of Conchology, vol. vi, p. 157.
Dignomia, HALL, 1871. Imperfectly known Forms among the Brachiopoda.

1839. *Lingula*, CONRAD. Second Ann. Rept. Palæont. Dept. N. Y. State Geol. Surv.
1842. *Lingula*, VANUXEM. Geology N. Y., Rept. Third District.
1842. *Lingula*, EMMONS. Geology N. Y., Rept. Second District.
1842. *Lingula*, CONRAD. Jour. Acad. Nat. Sci. Phila.
1843. *Lingula*, HALL. Geology N. Y., Rept. Fourth District.
1844. *Lingula*, OWEN. Geol. Rept. Iowa, Wisconsin, and Illinois.
1847. *Lingula*, HALL. Palæontology N. Y., vol. i.
1847. *Lingula*, DANA. American Journal of Science.
1851. *Lingula*, HALL. Foster and Whitney's Rept. Geol. Lake Superior.
1852. *Lingula*, HALL. Palæontology N. Y., vol. ii.
1852. *Lingula*, OWEN. Geol. Rept. Iowa, Wisconsin, and Minnesota.
1852. *Lingula*, F. RŒMER. Kreidebildung von Texas.

* Encyclopædia Britannica, 8th Ed., vol. xv, p. 301.

† Die Classen und Ordnungen des Thierreichs, p. 301. 1862.

‡ Annals and Magazine of Natural History, vol. xii, p. 15. 1873.

§ The synonymic lists accompanying these discussions are intended to give, first, the more important names under which the genera have been mentioned by European and American writers, followed by a table of references to notices in American literature of the genera or their species. Under the lesser groups, the lists are not thus divided, but will be found to contain all the important references necessary for the use of the student.

1856. *Lingula*, Billings. Canadian Naturalist and Geologist.
1856. *Lingula*, Emmons. American Geology.
1857. *Lingula*. Cox. Geological Survey of Kentucky, vol. iii.
1858. *Lingula*, Meek and Hayden. Proc. Acad. Nat. Sci. Phila.
1858. *Lingula*. Shumard. Trans. St. Louis Academy of Sciences.
1859. *Lingula*, Billings. Canadian Naturalist and Geologist.
1859. *Lingula*, Hall. Palæontology N. Y., vol. iii.
1860. *Lingula*, Hall. Thirteenth Rept. N. Y. State Cab. Nat. Hist.
1861. *Lingula*, Billings. Canadian Naturalist and Geologist.
1862. *Lingula*. Hall. Fifteenth Rept. N. Y. State Cab. Nat. Hist.
1862. *Lingula*, Billings. Palæozoic Fossils, vol. i.
1862. *Lingula*, White. Proc. Boston Soc. Nat. Hist.
1863. *Lingula*, Hall. Sixteenth Rept. N. Y. State Cab. Nat. Hist.
1863. *Lingula*. Hall. Trans. Albany Institute.
1863. *Lingula*, Winchell. Proc. Acad. Nat. Sci. Phila.
1865. *Lingula*. White. Proc. Boston Soc. Nat. Hist.
1865. *Lingula*. Billings. Palæozoic Fossils, vol. i.
1866. *Lingula*, Billings. Catalogue Silurian Fossils Anticosti.
1867. *Lingula*, Hall. Palæontology N. Y., vol. iv.
1868. *Lingula*. Meek. Trans. Chicago Academy of Sciences.
1868. *Lingula*, Meek and Worthen. Geological Survey Illinois, vol. iii.
1869(?) *Lingula*, Winchell. Proc. American Philosophical Society.
1872. *Lingula*. Meek. Rept. Palæontology Eastern Nebraska.
1873. *Lingula*, Hall. Twenty-third Rept. N. Y. State Cab. Nat. Hist.
1873. *Lingula*, Meek and Worthen. Geological Survey Illinois, vol. v.
1874. *Lingula*, Rathbun. Bull. Buffalo Soc. Nat. Hist.
1874. *Lingula*, White. Wheeler's Expl. 100th Meridian.
1874. *Lingula*, Billings. Palæozoic Fossils, vol. ii.
1875. *Lingula*. Nicholson. Rept. Palæontology Province of Ontario.
1875. *Lingula*, Meek. Geological Survey Ohio; Palæontology, vol. ii.
1875. *Lingula*, James. Cincinnati Quart. Journ. Science.
1875. *Lingula*. Hall and Whitfield. Geological Survey Ohio; Palæontology, vol. ii.
1875. *Lingula*, S. A. Miller. Cincinnati Quart. Journ. Science.
1878. *Lingula*. Rathbun. Proc. Boston Soc. Nat. Hist.
1879. *Lingula*, Emerson. Geol. Frobisher Bay, in Nourse's Narr. Hall's Arctic Expedition.
1879. *Lingula*, Hall. Descrip. New Spec. Fossils from the Niagara Group.
1880. *Lingula*, N. H. Winchell. Geological Survey Minn., Eighth Ann. Rept.
1880. *Lingula*, Whitfield. American Journal of Science.
1881. *Lingula*. Hall. Eleventh Ann. Rept. State Geologist Indiana.
1882. *Lingula*, Whitfield. Geology Wisconsin, vol. iv.
1884. *Lingula*, H. S. Williams. Bull. No. 3, U. S. Geological Survey.
1884. *Lingula*. White. Thirteenth Ann. Rept. State Geologist Indiana.
1884. *Lingula*, Worthen. Bull. No. 2, Illinois State Mus. Nat. Hist.
1884. *Lingula*. Walcott. Palæontology Eureka District.
1884. *Lingula*, Ringueberg. Proc. Acad. Nat. Sci. Phila.
1885. *Lingula*, Clarke. Bull. No. 16, U. S. Geological Survey.
1887. *Lingula*, Whiteaves. Geol. and Nat. Hist. Surv. Canada.
1888. *Lingula*, Herrick. Bull. Denison Univ., vol. iv, pt. 1.
1889. *Lingula*, Walcott. Proceedings of United States National Museum 1888.
1889. *Lingula*, Nettelroth. Kentucky Fossil Shells.

DIAGNOSIS. Shells sub-equivalve, equilateral; elongate-ovate, sub-quadrate or sub-triangular in outline; broad over the pallial region, cardinal slopes more or less conspicuous; slightly gaping at both extremities. Brachial or dorsal valve somewhat the shorter, and with a slightly thickened hinge-line. Surface of the shell smooth, or concentrically and radiately striated. Animal attached by a long, muscular pedicle protruding from between the beaks of the two valves.

Muscular impressions numerous, but usually indistinct. In the recent species they are twelve in number upon each valve, and are somewhat unsymmetrical in their arrangement. They may be designated as follows: The *umbonal* impressions (*g*), produced by a single muscular band passing directly across the cavity of the shell near the beaks, and by their contraction opening the valves; the *lateral* impressions, which are produced by three pairs of muscles, the *anteriors* (*j*) passing from near the lateral boundaries of the visceral area on the pedicle-valve, forward to the anterior extremity of this tract on the brachial valve; the *middles* (*k*) passing in just the opposite direction, from the anterior region of the pedicle-valve to the lateral region of the brachial; the *externals* (*l*) passing from the ante-lateral region of the pedicle-valve to the post-lateral region of the brachial valve, these muscles serving to move the valves forward and backward. The *central* impressions (*h*) are produced by a single pair of muscles extending across the antelateral region of the visceral area, and by the contraction of these, the valves are closed. The *transmedian* impressions (*i*), are made by a triple muscle, one band of which is on one side the visceral area, the other two on the other side, the two lateral components crossing each other in passing from the posterior region

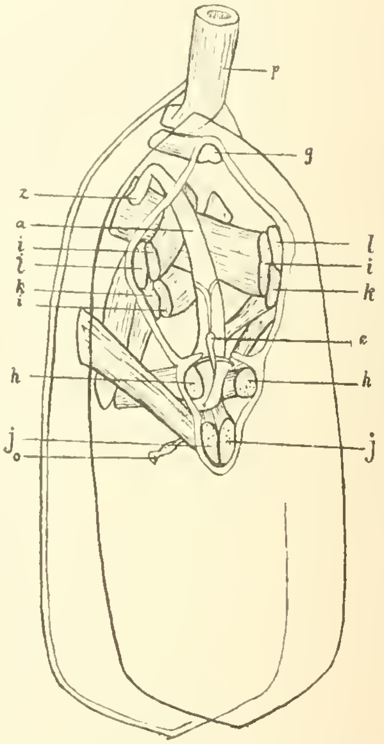


FIG 1. *Lingula anatina*, after HANCOCK. *p*, pedicle; *g*, umbonal muscle; *h*, centrals; *i*, transmedians; *j*, *k*, *l*, laterals (*j*, anteriors, *k*, middles, *l*, externals); *e*, heart; *o*, mouth; *a*, alimentary canal; *z*, anus.

of the pedicle-valve to the medio-lateral region of the opposite valve. By the action of these muscles the animal is able to slide apart the anterior and posterior extremities of its valves.* The muscular region in each valve is surrounded by the *parietal* bands (*b*), which leave more or less distinct impressions upon the shell.

The anterior internal surface of each valve bears traces of two strong pallial sinuses, which nearly meet in the axial line before reaching the anterior margin. In front and behind are radiating vascular markings.

Shell substance composed of alternating lamellæ of chitinous and calcareous material.

Type, *Lingula anatina*, Lamarck.

Observations. Few of the larger genera of the brachiopoda form so integral a group and present so well defined limitations as the genus Lingula. Notwithstanding, however, the compactness of the genus, the discrimination of palæozoic species is frequently attended by very great embarrassments, arising from the tenuity of the shell, its liability to distortion in process of fossilization, the general similarity in the matter of external ornamentation, and the usual obliteration of the definition of the muscular scars by maceration or from the character of the matrix.

Primarily, the shells of palæozoic Lingulas present two extremes of variation in outline, (*a*) an acuminate or sub-triangular form, in which the rostral area is very narrow, with long, sloping post-lateral margins, and a rounded or transverse anterior margin; (*b*) a sub-quadrate form, with the posterior or rostral margins converging toward the beak. The passage-forms between these extremes present outlines varying from ovate to elliptical, and here the great majority of species is to be assigned. While all these variations in form have maintained a contemporaneous existence in palæozoic time, the acuminate type (*a*), prevailed both numerically and specifically in the earlier faunas (*L. acuminata*, in the Calciferous sandstone; *L. attenuata*, in the Llandeilo; *L. crumena*, in

* Among authors there has been a confusing variety of nomenclature for the muscular system in Lingula. The one that is used here is proposed by Professor William King, and, in its simplicity, has claims for adoption.

the Llandovery: *L. Daphne*, *L. riciniformis*, in the Trenton: *L. Rouaulti*, *L. Hawkii*, in the Budleigh-Salterton pebbles [Lower Silurian]; *L. perovata*, in the Clinton: *L. cuneata*, in the Medina sandstone; *L. spatiosa*, in the Lower Helderberg), diminishing during the Devonian (*L. Leæna*, in the Hamilton), and reaching the close of the Palæozoic with a very meager representation (*L. Scotica*, *L. flabellula*, in the Carboniferous); and of the various types of outline, this is the only one not represented among living species of the genus.

The generic term LINGULA, like many other names among the fossil brachiopods, has long been a receptacle for various fossils, which, in the absence of knowledge of their internal characters, have been assumed to be congeneric. Recent observers have, however, made great progress toward a correct understanding and limitation of the group. Many species of acuminate form originally referred to LINGULA, have been found to differ so distinctively, in essential features, from the type species, *L. anatina*, that the erection of various other generic groups has been necessary; *e. g.*, LINGULELLA, Salter, LINGULEPIS, Hall, GLOSSINA, Phillips, etc. To some of these newer genera, probably belong most of the species from the primordial faunas, which have been described as "LINGULA," a doubt resting upon all the species thus referred, whose interior markings are not known. Thus, *L. ampla*, Owen, *L. Winona*, and *L. Mosia*, Hall, from the Potsdam sandstone of Wisconsin, have the external characters of LINGULA, and must, of necessity, be regarded as members of the genus, until the difference has been demonstrated from internal characters. Likewise, in the British primordial faunas are the species, *L. squamosa*, Holl, *L. pygmæa*, Salter, and *L. petalon*, Hicks, of which we have still to learn the true generic relations. The fact that as far as the internal characters of the species of the earliest faunas have become known they have shown generic differences from LINGULA, may, to a certain degree, justify the temporary reference of the species mentioned to some other group.

This genus has been most remarkable for its wonderful adaptability to change in the conditions of life through immeasurable lengths of geological time, and, though in its strict limitation it may not have been represented in the earliest

faunas appearing on the earth, its persistence in time is nevertheless unequaled by that of any other known genus of organisms.

The palæozoic Lingulas, *sensu stricto*, have not shown variations of sufficient importance to permit a thoroughly satisfactory subdivision of the genus. As the interiors and muscular scars of different species become known, they reveal a closer alliance with one another, and with the recent type of the genus, than had been suspected.

There is a growing tendency among authors to remove certain species from this genus to LINGULELLA on account of an apparent inequality in the valves of the shell, accompanied by a cardinal area on the pedicle-valve, which seems to be grooved or depressed from the apex forward. Great care is needed in the accurate determination of these features. The type species, *Lingula anatina*, has not only gaping and slightly unequal valves, but the pedicle-valve has a distinct cardinal shelf or area, divided longitudinally by a depression widening from the apex anteriorly, and termed by KING* the "deltidium." This, according to Professor KING, is usually not well developed, and in the average specimens of *L. anatina* found in museum collections, appears to be partially or quite wanting, from accidental causes. The deltidium is bounded at the sides by elevated ridges, which, at the anterior ends, are each developed into a small callosity. "The ridge-callosities are no doubt insignificant; nevertheless they appear to be the rudiments of important structures. Apparently they have become so far developed in *Lingula Lesueuri*, as to serve to articulate the valves. If I am correct . . . . . this species cannot belong to the genus in which it has been placed."† In the opposite or brachial valve is a slight area without a deltidium, but bearing concentric growth-lines, and a very faint longitudinal groove.

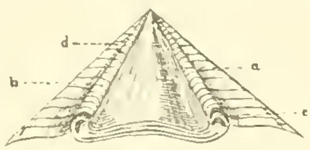


FIG. 2. *Lingula anatina*; cardinal area of pedicle-valve, after KING. *a*, deltidium; *b*, deltidial ridges; *c*, deltidial callosities; *d*, areal borders.

It is to be expected that we shall find similar features more or less developed among the fossil Lingulas. The broad, depressed deltidium of *L. anatina*

* Annals and Magazine of Natural History, July, 1873.

† KING, *loc. cit.*, p. 13.

is not to be confounded with the deep pedicle-slit in LINGULELLA. Furthermore, a slight longitudinal displacement of the valves before, or while undergoing fossilization, will frequently exaggerate the normal extension of the umbonal region in the pedicle-valve, beyond that in the opposite valve. We are disposed to consider the current reference to LINGULELLA of several well-known American species, *e. g.*, *L. Iowensis*, Owen,* *L. Covingtonensis*, Hall and Whitfield,† *L. Norwoodi*,‡ James, *L. Vanhornii*, Miller, as incautious, and feel that, in general, these are more safely left under the original genus. Two of the species named, viz., *L. Iowensis* and *L. Vanhornii*, have muscular impressions comparable with those of *L. anatina*, and of widely different character and arrangement from those in the genus LINGULELLA, Living Lingulas, are known to form a tube about the pedicle by the agglutination of grains of sand or other sedimentary débris, after the manner of *Tubifex* and other forms of Chætopod Annelids. (See accompanying figure of *Lingula pyramidata*,§ Stimpson, after MORSE, which shows this tube, as well as the effect of the action of the sliding or *transmedian* muscles in swinging the valves laterally asunder.)

FIG. 3. *Lingula (Glottidia) Audebarti.* After MORSE.

* *Lingulella Iowensis*, Whitfield, Geol. Wisconsin, vol. iv, p. 242. 1883.

† Mr. S. A. MILLER, in his "Catalogue of the Fossils found in the Hudson River, Utica Slate and Trenton Groups, as exposed in the South-east part of Indiana, South-west part of Ohio, and Northern part of Kentucky": Tenth Ann. Rept. Geol. Surv. Indiana, says, on page 19, under the heading LINGULA: "All the species referred to this genus" [in the groups mentioned] "belong to *Lingulella;*" and in Mr. J. F. JAMES' "Catalogue of the Fossils of the Cincinnati group," 1881, in addition to the species mentioned above (excepting *L. Covingtonensis*), *L. attenuata*, Sowerby, and *L. riciniformis*, Hall, are referred to the *sub-genus* LINGULELLA.

‡ This species belongs to the genus LINGULOPS.

§ *Glottidia Audebarti*, Broderip. DAVIDSON, Trans. Linnean Society, Second Ser., Zoology, vol. iv, part 3, p. 223.

The retention, in the fossil state, of the pedicle, is a rare occurrence. Of palæozoic species, Mr. Davidson* has figured an example of *L.? Lesueuri*, in which the impression of this organ is very distinctly shown. More recently, Mr. Walcott† has described a beautiful example of *L. æqualis*, Hall, in which the narrow arm is seen protruding from the aperture in the cardinal area. By the favor of Dr. J. S. Newberry, we have been allowed to figure a specimen from the Waverly sandstone at Oil City, Penna. (see Plate IV K, fig. 7), in which the pedicle is also distinctly visible. The species is the one identified as *L. Scotica*, Davidson, by the Ohio geologists, and more recently described by Mr. Herrick‡ as *L. Waverliensis*.

Fig. 4
Lingula æqualis, Hall.
With pedicle
After Walcott.

Fig. 5.
Lingula ? Lesueuri, Rouault.
With pedicle.
After Davidson.

In regard to the myology of the palæozoic Lingulas, we have satisfactory evidence that the arrangement of the muscles did not differ widely from that in recent members of the genus. It is, however, not often that a palæozoic specimen is found which has retained upon the surface of the shell, or left upon the matrix, traces of the delicate muscular scars; and in such instances usually only the stronger impressions are discernible. A few examples have been figured by recent American writers, which retain, in exquisite detail, not only the muscular, but also the pallial impressions of the shell. Of these, one is a brachial valve of the *L. Whitii*, of Walcott, figured in his Palæontology of the Eureka District; § another, an internal cast, representing the impressions on both dorsal and ventral valves of *L. Elderi*, Whitfield, figured by the author first, in the American Journal of Science,|| and subsequently in the Report of the Geological Survey

* Brachiopoda of the Budleigh-Salterton Pebble-bed, p. 362, pl. xl, fig. 16.

† Proceedings of the United States National Museum, for 1888, p. 480, fig. 3.

‡ Bull. Denison Univ., vol. iv, pt. 1, p. 18, pl. iii, fig. 1. 1888.

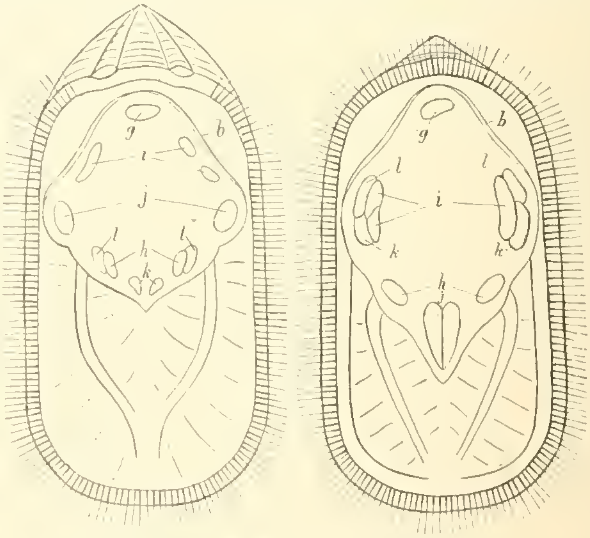
§ Page 109, pl. xiii, fig. 3, and pl. xxi, fig. 19. 1884.

|| Vol. xix, p. 473. 1880.

of Wisconsin.* Upon the first plate of this volume are given, in addition to copies of the figures named, a number of illustrations representing these impressions in different degrees of completeness: especial attention may be directed to the figures of *L. punctata*, *L. Procteri*, *L. densa*, and to those of *L. lamellata*, upon Plate IV K. (See, also, the figures of *L. Lewisi*, Sow., given by DAVIDSON,† and the accompanying text illustrations of extremely well preserved internal casts of *L. Melie* [brachial valve], and *L. paracletus*, sp. nov. [pedicle-valve].)

There has been a considerable diversity of opinion among authors, in regard to the special functions of the various muscular bands in LINGULA. Few investigators have brought to the study of this subject the clear insight and incisive judgment of Professor WILLIAM KING, whose nomenclature of the muscles, we have preferred to adopt.

The first strong impression arising from the comparison of these ancient forms with the type-species is that in the former, the dorsal scars of the *central* muscles (*h*) are relatively much the larger, and are situated somewhat posteriorly, apparently encroaching upon that portion of the visceral chamber which, in *L. anatina*, is occupied by the essential organs of the animal. This apparently great size, however, is somewhat illusory, as undoubtedly a portion of these large scars is due to their continued advance as the shell increases in age, and probably at no time in the mature life of the animal did these muscular bands, at their origin and insertion, cover the entire



Lingula anatina, after DAVIDSON.
FIG. 6. Pedicle valve. FIG. 7.‡ Brachial valve.
b, parietal scar; *g*, umbonal muscle; *i*, transmedians, *h*, centrals; *j*, *k*, *l*, laterals (*j*, anteriors; *k*, middles; *l*, externals).

* Vol. iv, p. 315, pl. xxvii, figs. 3-5. 1882.

† Monogr. British Silurian Brach., pl. iii, figs. 5, 6.

‡ DAVIDSON'S figures are diagrammatic copies of the more elaborate illustrations given by KING. In the process of copying it is evident that fig. 7 has been reversed, and the position of the double and single muscular bands of (*i*) inverted.

scars. The same may be said of the other scars, all of which show something of this progressive increase in size. The impressions which appear to be most generally retained among the fossils are the *anterior laterals* (*j*) of the brachial valve, and the *middle laterals* (*k*) of the pedicle-valve. These lie in the ante-median portion of the valves, and, in their progress forward, have left long, conspicuous tracks which follow the axis of the shell.

The separate members of these pairs of impressions are not always, or even often, to be distinguished, the long axial impression accompanied by the anterior portions of the broad *centrals* being usually all that is visible of the muscular scars. The subdivision and asymmetry of these scars in *L. anatina* has been determined only by the aid of the attached muscular bands. Without their assistance it would prove difficult, if not impracticable, to ascertain their exact limitations, merely from the impressions upon the shells. This will, to a certain degree, be made evident by comparing Professor KING's figures with those of the same species given on Plate I; in the latter drawings the scars have been somewhat emphasized, but it is impossible to resolve, with any degree of accuracy, the compound lateral and transmedian scars (*k*, *l*, *i*, in the brachial, *j*, *i*, in the pedicle-valve). Nevertheless, in the brachial valve of *L. Whitii*, the compound lateral scar is quite distinct, and the umbonal (*g*) impression well defined. On the brachial valve of *L. Elderi*, Mr. WHITFIELD has shown the former to be even more clearly defined than in *L. Whitii*, and the umbonal scar to be unusually large. In both these species, the laterals and transmedians are situated considerably nearer the umbonal region than in *L. anatina*. The pedicle-valve of *L. Elderi* shows the transmedian scars, which are represented as two on each side, the anterior of which is regarded by the author as the scar of the "posterior adjustors" (transmedian) and "anterior adductors" combined. *Lingula punctata* shows comparatively broad muscular scars in this region, but it has been impossible to resolve them satisfactorily. The umbonal scar also appears on the pedicle-valve of *L. Elderi*.

A species of LINGULA from the Cuyahoga shale at Johnstown, Chardon, and elsewhere in Ohio, which has usually been confounded with the common *L. Melie*

of these beds, but is described in the concluding pages of this work as *L. paracletus*, sp. nov., has afforded the most complete and satisfactory representation of the system of muscular scars. The pedicle-valve here figured is drawn from a cast of the interior, which shows not only the centrals (*h*), middle laterals (*k*), but the distinctly specialized outside laterals (*l*), anterior laterals (*j*), the transmedians (*i*), and the great umbonal (*g*).

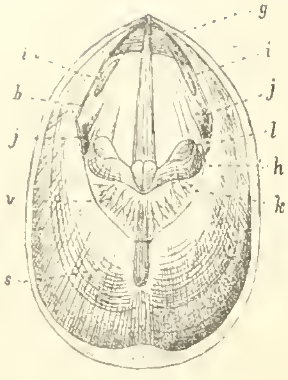


FIG. 8
Lingula paracletus, sp. nov.
Interior of pedicle-valve.

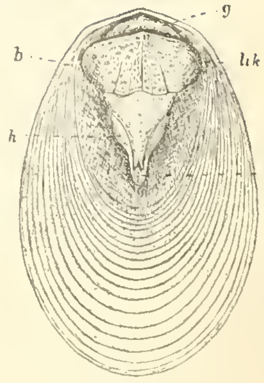


FIG. 9.
Lingula Melie, Hall.
Interior of brachial valve.

Even the asymmetry of the transmedians (*i*) is apparent in the unequal size of the impressions, that on the left in the figure (corresponding to the right, when looking into the interior of the valve) being noticeably larger than its correlate. In the brachial valve, the scars are essentially like those in the corresponding valve of *L. Melie*, shown in the accompanying figure, but are not placed quite so far back. Here the laterals (*l*, *k*) and transmedians (*i*) are coalesced, and show a tendency to spread transversely over the visceral region, a feature sometimes noticeable in other palæozoic species, and probably of similar nature to that seen in *Barroisella subspatulata* (Plate I, fig. 16).

As far as the vascular markings of the brachiocœle in the fossil species have been observed, they appear to have been in full agreement with those of the living type. In *L. Whitii*, *L. Elderi*, *L. punctata*, *L. cuneata*, and *L. lamellata* the large pallial sinuses are to be seen passing forward from the parietal band, or the position of the compound lateral scars, approaching each other until they nearly or quite meet in front. The outer ramifications from these large trunks, and, in *L. Elderi* and *L. cuneata*, the inner also, are discernible. In the brachial valve of *L. Elderi* are seen the vascular impressions of the pleurocœles, which lie in the post-lateral portion of the internal cavity, outside the parietal band. In *L. Procteri* and *L. paracletus*, the anterior vascular branches appear to radiate from the edge of the central muscles, as though the pallial trunks

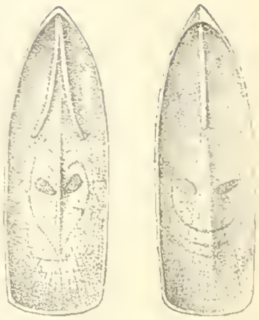
passed closely about their insertion, a feature which requires confirmatory evidence.

In so far, then, as the impressions upon the shell, left by the soft parts of the animal are concerned, we find a close correspondence in the existing and palæozoic members of this genus.

We turn now to a consideration of the *septal markings* on the interior of these shells. When the soft parts are entirely removed from the shell of *L. anatina*, the pedicle-valve shows a broad, low, longitudinal ridge, whose margins are sharply incised along the posterior portion, but become elevated with the elevation of the entire ridge anteriorly. This ridge terminates in front of the center of the shell, and bears, at its excavate extremity, the impressions of the middle-lateral muscles, being buttressed on either side behind these, by the large scars of the centrals. From the posterior extension of this ridge diverge two more or less distinct longitudinal callosities, which are the inner boundaries of the transmedian impressions, or the raised margins of the parietal scars. In the opposite, or brachial valve, a longitudinal ridge is more or less developed toward the posterior portion of the shell, but becomes flattened over the central visceral region, whence it is produced much further forward than in the opposite valve, and is sharply elevated. Its terminal portion separates the anterior lateral scars, directly behind them lying the central muscular impressions. With these features in mind, we must expect to find the true palæozoic Lingulas showing evidence, to a certain degree at least, of such internal ridges and callosities. In regard to these shell-ridges, KING has said: "The muscles, including the parietals, produce scars, often well seen in the valves of recent Lingulas. The scars are occasionally liable to become raised at their margin, giving them the appearance of individualized muscular fulcra or myophores. A specimen before us has the scar of one of the post-lateral parietals with its inner margin completely raised in the form of a plate. Such cases are evidently of abnormal formation; but they explain the origin of what may be assumed as normal cases—for example, *Lingula albida*, in which there are two of the same kind of plates "*

* On Some Characters of Lingula anatina. p. 8.

On the basis of the above mentioned peculiarity, Mr. DALL has separated such forms as *L. albida* from the genus LINGULA, under the generic term GLOTTIDIA,* *i. e.*, shells in which the pedicle-valve bears two diverging parietal ridges and the brachial valve a median ridge of about the same length. Representatives of Mr. DALL'S genus have been regarded as confined to living species,† and as representing the genus LINGULA in American seas.



FIGS. 10, 11.
Glottidia Palmeri, after DAVIDSON.
Fig. 10. Pedicle-valve.
Fig. 11. Brachial valve.

The name DIGNOMIA was proposed in 1871 for certain Devonian and Silurian species, which are characterized by a strong longitudinal septum in "one or both valves."‡

Type, *Lingula alveata*, Hall, of the Hamilton shales.

In this species, the median septum is sometimes strong and sharp, sometimes broad and low, with raised margins precisely as in the pedicle-valve of *L. anatina* (see figures of the species, Plate I). In addition, however, to the median septum, *L. alveata*, the type species, shows distinct evidence of diverging parietal ridges, and, moreover, is the only American fossil species that is known to retain these as a persistent feature. The presence of the longitudinal septum alone in some degree of development, is by no means a rare feature among the palæozoic species, and, as before observed, specimens frequently give evidence of the fact that this has been partially or wholly formed by progressive accretions to the anterior or median muscular fulcra. (See further on this point the observations on the formation of the platform in the Trimerellids.) Thus it has attained different degrees of development in *L. quadrata* of the Trenton, *L. Iowensis* of the Galena limestone, *L.*

* American Journal of Conchology, vol. vi, p. 157, pl. viii, figs. 1–6. 1870.

† Mr. DAVIDSON calls attention to the close similarity apparent in *Glottidia Palmeri*, Dall, and *Lingula? Lesueuri*, Rouault, in respect to these septal ridges. (Brachiopoda of the Budleigh-Salterton Pebble-bed, p. 362.) We have just referred to Prof. KING'S suggestion that the latter species should be placed in a distinct genus, on account of its strong deltidial callosities, apparently adapted for the articulation of the valves, and it will probably prove a representative of the genus BARROISELLA (q. v.).

‡ HALL, On some Imperfectly known Forms among the Brachiopoda. 1871.

Procteri of the Hudson group, *L. cuneata* of the Medina sandstone, *L. centrilineata* of the Lower Helderberg, *L. punctata*, *L. Delia* and *L. densa* of the Hamilton, etc. While in many cases it has not been observed and in other species is known not to exist, it must be borne in mind that all specimens of *L. anatina* do not show the internal ridges with equal distinctness, and that not infrequently they are all obsolescent. It will therefore be a matter of much difficulty, if it be possible, to fix upon features of permanent taxonomic value in the development of these septal ridges.

In DIGNOMIA (*L. alveata*) it is an important fact that both median and lateral ridges appear to be nearly equally developed in both valves, and herein lies a distinctive difference between this form of development and that characterizing either *Lingula anatina* or GLOTTIDIA. It would not be prudent to attempt a further sub-division of LINGULA on septal features alone, although one cannot but recognize the great differences of development in these respects. DIGNOMIA, however, may be tentatively accorded a sub-generic value until its further relation to, or divergence from LINGULA can be demonstrated.

In 1848, PHILLIPS proposed to place such forms of LINGULA as *L. attenuata*, Sowerby, and *L. crumena*, Phillips, in a separate group under the designation GLOSSINA.* The author seems not to have given a diagnosis of the characters of the division, but evidently intended to include in it a pretty well defined group of forms. Our knowledge of the internal characters of these earlier acuminate forms is very imperfect, as they have rarely given any indication of muscular impressions or septal markings, and it may eventually be advisable to separate this group from typical Lingulas, under the name proposed by PHILLIPS. We must not overlook the fact that *L. cuneata* has shown muscular scars having the general character of those in *L. anatina*, but this species deviates slightly in the sub-quadrate tendency of its outline from the group of sub-trigonal forms constituting GLOSSINA. Mr. DAVIDSON has also shown that similar scars exist in *L. Hawkii*, Rouault, a species having the broadly spatulate character seen in *L. flabellula*† and *L. Scotica*.

* Mem. Geol. Surv. United Kingdom, vol ii, pt. 1, p. 370.

† For description, see Supplement.

We are not aware that any author has described or represented the form and size of the egg of the recent LINGULA since the publication of Professor OWEN's observations "On the Anatomy of Terebratula," in DAVIDSON's "Introduction to the British Fossil Brachiopoda," 1853. On plate i of this work, figures 7, *a*, *b*, *c*, *d* and *e*, are given representations of the ova after impregnation has been effected, which indicate that their form in this condition is elongate-ovoid or sub-trihedral (7 *c*). According to LACAZE-DUTHIERS, the egg of THECIDIUM, in its earliest observed condition, is somewhat pyriform.* MORSE describes the eggs of TEREBRATULINA as "generally kidney-shaped, though very irregular as to form and size."† As to the actual size of the ova discussed by these authors, OWEN's figures, enlarged one hundred and twenty diameters, would indicate a length of .1¼ mm. MORSE has given no exact measurements of these bodies: the youngest embryo in which the shell is developed, is about .3 mm. in length, and it is fair to assume that the ova are considerably smaller. On removing the shell from a specimen of *Lingula lamellata*, Hall, from the Niagara limestone at Hamilton, Ontario, in order to determine the character of the muscular scars, the interior filling, a compact, fine-grained calcareous mud, was found to be filled with minute ovoid bodies. The valves of the shell were in the normal apposition and in contact about the entire periphery. The bodies referred to (*ova*, as we believe them to be), vary somewhat in size and shape, their length being from .3 to .5 mm., their form elongate-ovoid or ellipsoidal. They are closely crowded together, but seldom in actual contact, the interspaces being filled, not with the mud of the sediment, but with a translucent crystalline calcite. They are most abundant wherever the pallial sinuses have extended, but in the marginal regions have been crowded inward by the intrusion of the sediment. A section of the interior of the filling shows that these bodies had evidently been set free into the perivisceral cavity, and have also found their way into the visceral region after the decomposition of the softer parts of the animal. That they are not of oölitic or foraminiferal nature is demon-

* Annales des Sciences Naturelles, 4th Ser., vol. xv, p. 302. 1861.

† On the Early Stages of Terebratulina Septentrionalis: Memoirs of the Boston Society of Natural History, vol. ii, page 31, pl. i, fig. 1. See, also, Embryology of Terebratulina, *op. cit.*, pp. 251, 252, pl. viii, figs. 1–5.

strated by a thin transverse section, which shows them to be simply opaque masses without evidence of structure save a thin transparent external covering. Enlarged figures of this internal cast and of the ovoid bodies are given upon Plate IV K.

On account of the extreme tenuity of the shell in the fossil Lingulas, it is difficult to ascertain its structure from sections. The shell-substance is essentially corneous, and the mineral intermixture is calcic phosphate with traces of calcic and magnesic carbonates.

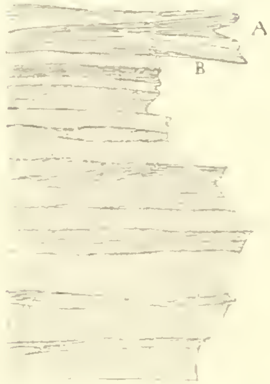


FIG. 12. Magnified section of the thickest portion of the shell of *Lingula anatina* from DAVIDSON, after GRATIOLET. *A*, corneous layers. *B*, mineral layers with vertical canals.

The organic and inorganic constituents are arranged in alternating lamellæ, the former, according to GRATIOLET,* having a fibrous structure, and the latter being traversed by numerous microscopic canals. A finely preserved specimen of an undetermined species from the Waverly sandstone at Pierrepont, Ohio, shows strong punctæ, visible to the naked eye on the internal surface, where, according to the author above cited, the calcareous layers of the test are thickest. The same character is also seen in the specimen figured on Plate IV K (fig. 19), an undetermined species from the Black shale of Madison county, Kentucky. The laminæ of the shell have exfoliated, exposing the internal cast, which is covered with minute papillæ, apparently the fillings of the inner openings of these tubes. It would, therefore, seem that these vertical canals have sometimes attained a greater development in the extinct than in the living species.

The surface ornamentation is subject to but little variation, usually consisting of concentric lines marking the successive stages in the growth of the shell. From the paucity of external characters, arises much of the difficulty attending the determination of species, similar in their general aspects. Still, a few species, exceptions to the rule, have a striking shell-ornamentation. In *L. punctata*, of the Hamilton group, the fine surface lines are

* Journal de Conchyliologie, 2d ser., vol. viii, p. 59. 1860.

wrinkled into a sort of herring-bone pattern: *L. distincta* and *L. epimia*, Barrande. *L. granulata*, Phillips, and *L. tenuigranulata*, McCoy, also have very characteristic surface markings, consisting of granulations or tubercles with various arrangements. In the *L. lamellata*, Hall,* from the Clinton group of central New York, and the commingled Clinton and Niagara fauna at Hamilton, Ontario, the surface is covered by broad, transverse, imbricating, gently undulating lines, which do not correspond with the curvature of the anterior margin, but end quite abruptly on the lateral margins. Near the umbo these lines are crossed by the concentric growth-lines of the shell. Of precisely the same character is the ornamentation in *L. zebra*, Barrande, from the Bohemian Etage E,† and closely similar to it is that of *L. spathata*, Hall, of the Lower Helderberg.

The genus Lingula reached its culmination of development in the faunas of the Silurian and Devonian. In the Palæozoic of North America alone, about one hundred and twenty species (making allowance for synonyms and the necessary elimination of heterogeneous forms) are now recognized. Of these about seventy are from the Silurian. It is not probable that as many more species are known from the same formations in other countries.

Genus LINGULOPS, Hall. 1871.

PLATE II, FIGS. 24-29; AND PLATE IV K, FIGS. 14, 15.

1871. *Lingulops*, Hall. Notes on some New or Imperfectly known Forms among the Brachiopoda, etc. (March). In advance of Twenty-third Rept. N. Y. State Cab. Nat. Hist.
1872. *Lingulops*, Hall. *Idem*. (March). Reprinted with Explanations of Figures.
1873. *Lingulops*, Hall. *Idem*. Twenty third Rept. N. Y. State Cab. Nat. Hist., p. 245.
1874. *Lingulops*, Davidson and King. Quart. Journ. Geol. Soc., vol. xxx, p. 164.
1875. *Lingula*, U. P. James. Cincinnati Quart. Journ. Sci., vol. ii.

Of this remarkable and interesting genus but three representatives are known. Two of these are from faunas probably equivalent, but from widely distant localities; *Lingulops Whitfieldi*, the type-species, from a chocolate-brown

* This name has been applied to two distinct species, one from the Clinton group (Pal. N. Y., vol. ii, p. 55, pl. xx, figs. 1 *a, b, c*), the other from the Niagara shales at Lockport and elsewhere (Geol. Rept. Fourth Dist. N. Y., 1843, p. 109, fig. 2; Pal. N. Y., vol. ii, 1847, p. 249, pl. liii, figs. 1 and 2). The latter has priority, and the former, that above mentioned, may receive the designation, *Lingula tæniola*.

† Syst. Sil., vol. v, pl. 105, fig. v.

or reddish sandy shale found on the Maquoketa creek, twelve miles northwest of Dubuque, Iowa, and the *Lingula Norwoodi*, of the late U. P. JAMES, from southern Ohio and northern Kentucky; both being from rocks now referred to the age of the Hudson group. The third species is one here described* from the Niagara limestone at Hamilton, Ontario, *L. Granti*. All the shells are of small size, rarely exceeding 6 mm. in length, and all have essentially the same external aspect, but the internal casts, often retaining the character of the muscular markings in exquisite detail, show important peculiarities for each species. Of the original species, *L. Whitfieldi*, very few specimens have been obtained. In the first notice of the genus† the diagnosis given was very brief, and in the following terms:

"The ventral (?) valve presents a small area with a narrow pedicel groove, and a large lobed muscular impression, which in the cast extends as a narrow groove towards the base of the shell. The character of the area and foramen differ from the typical forms of *Lingulella*, though in that genus the form and character of the muscular impression has not been determined, so far as I am aware. For this shell I propose the name *Lingulops*."‡ [Pl. xiii, fig. 2.]

Shortly after the first publication of this notice, in March, 1871, gutta-percha impressions, taken from the single internal cast of *L. Whitfieldi*, which had served the purpose of the original illustration of the genus, were sent by his request, to Mr. DAVIDSON, and upon these was based the analysis of LINGULOPS given by DAVIDSON and KING, in the appendix to their paper on the Trimerellidæ.§ The minuteness of these fossils requires the greatest care in the determination of their internal markings, and the diversity of opinion which has already been expressed, both in words and illustration, in regard to these features in the type-species, must be, to an important degree, due to the personal equation in observation. Upon plate xix, accompanying the paper of Messrs. DAVIDSON and KING, a lithographic figure (fig. 9*a*) is given of the single interior then known, agreeing, except in some minor details, with the original illustra-

* See Supplement.

† Imperfectly known Forms among the Brachiopoda, etc. 1871.

‡ "Printed *Ligulops* by mistake in some copies of the paper."

§ Quart. Journ. Geol. Soc., vol. xxx, p. 164. 1874.

tion.* But neither of these figures proved satisfactory to the authors, and they inserted an additional figure in the text (p. 165). The figure which is now given of this valve (Plate 11, fig. 28) has been made with great care from the original specimen, and is reduced from a camera drawing. Though it differs in some respects from previous figures, the accuracy of its details is supported by internal casts of other specimens of the same valve, though none are so clearly developed as in the original specimen. Notwithstanding the great value of the observations by the English authors upon the structure and generic relations of this species, it must be said, that, of all the illustrations which have been given of the original valve, the wood-cut referred to, represents the interior features with the least accuracy.

Both valves of LINGULOPS have a relatively broad cardinal area, which is divided transversely into two parts, (*a*) a smooth, narrow, apical portion ; (*b*) a broad inner band, along which the valves appear to have been in contact. In *L. Whitfieldi*, this band is flattened and projects into the interior cavity of the shell, like a narrow lunate shelf; on the pedicle-valve it is concentrically striated, while, in *L. Norwoodi* and *L. Granti*, it is smooth, and not flat but gently convex. The pedicle-groove crosses this inner area only, not encroaching on the apical area of either valve ; in the pedicle-valve of *L. Whitfieldi* it is sharp and narrow, in the brachial valve, broad and faint ; while in the pedicle-valve of *L. Norwoodi*, it is very indistinct, and not discernible in the opposite valve.

Directly in front of the cardinal area, is a narrow crescentic ridge, the anterior margin of which is deeply excavated. This ridge, which is parallel and co-extensive with the cardinal area, bears a median angulation, projecting backward toward the pedicle-groove. This feature is more clearly defined in *L. Whitfieldi* than in any specimens of *L. Norwoodi* that we have examined, but it is evident in the pedicle-valve of this species also, where it is interrupted beneath the beak by a thickened area which may represent the position of the

* The original figure was drawn from a natural cast to which a portion of the shell adhered. DAVIDSON and KING's figure, being made from a gutta-percha impression, gave the interior markings in their natural relief.

umbonal muscle. No LINGULA possesses this peculiar cresentic ridge, but it is a feature strongly developed and of great importance in the various genera constituting the *Family* TRIMERELLIDÆ, of DAVIDSON and KING, and in this respect, as well as in others to be directly noticed, LINGULOPS is a Trimerellid.

In the arrangement of the internal impressions on the pedicle-valve, within the crescent, there is a general similarity to LINGULA. An elongate median impression, evidently the progressive scar of the muscles homologous with the middle laterals of LINGULA, is accompanied, on either side, by scars of the central muscles, and outside of these lie faint scars (much better defined in *L. Norwoodi* than in *L Whitfieldi*), which may be ascribed to the outside laterals.*

These median scars have a sharply elevated anterior edge, but otherwise their surface is depressed in the older species, *L. Whitfieldi* and *L. Norwoodi*, while, in *L. Granti*, the muscular area is thickened over its entire surface, forming an incipient platform. From the anterior edge of this area, extends a median septum, sometimes of considerable length. This, in *L. Whitfieldi*, is accompanied, on either side, by a deep groove, outside of which lies a broad and low rounded ridge.

In LINGULA, the median septum does not attain such a development in the pedicle-valve, except in forms referable to DIGNOMIA, where it extends forward from the posterior extremity without interruption. In the brachial valve† of LINGULA,

* In regard to the nomenclature of the muscular and other impressions in the platform-bearing inarticulates, it seems best to adopt that proposed by the English authors, though it is purely arbitrary and conveys no correct impression of the functional relation of these parts to those of LINGULA. In the pedicle-valve of TRIMERELLA, the *anterior* and *median* scars correspond in position to the *middles* (*k*) of LINGULA; the *laterals* to the *centrals* (*h*), and *outsiders*, or *externals* (*l*); the *terminal* scars of the *crescent* to the *anteriors* (*j*) and *transmedians* (*i*): in the brachial-valve, the *anteriors* and *medians*, to the *anteriors* (*j*): the *laterals* to the *centrals* (*h*), and the *crescent* scars to the *middles* (*k*) and *transmedians* (*i*). LINGULOPS shows a very clearly defined transition stage between these genera in muscular characters, and though it has been impossible to demonstrate, from observation, the existence of the transmedian muscles in the Trimerelloids, as no specimen has been seen which indicates that the lateral scars of the crescent are unsymmetrical, the same fact is true of fossil Lingulas generally, and in default of other evidence, we are left to infer that the muscular functions in all these forms were essentially similar.

† Messrs. DAVIDSON and KING were strongly convinced that the original specimen of *L. Whitfieldi* should be regarded as the *brachial* rather than the pedicle-valve. Their opinions, which are entitled to the most respectful consideration, are essentially these: The slit upon the cardinal area, which we have termed the pedicle-groove, was very faintly defined in the impressions at their disposal, and they regarded it as a depression, "nothing more than such as occasionally occurs in the brachial valve of *Lingula anatina*" (p. 166). Furthermore: "In the pedicle-valve of TRIMERELLA the crown of the crescent has a *forward* curve

however, there is a distinct development of the septum in this anterior portion of the shell, such as is also to be found in both valves of some Trimerellas.

The posterior outline of the muscular region in the pedicle-valve is very striking. It consists of a central lobe or scallop, at each side of which is a somewhat broader lobe, continuous with the faintly defined lateral muscular scar. It seems evident that this lobed impression, which has been aptly compared, by Davidson and King, to a Moorish arch, is of muscular origin and made by separate muscular bands. This appears from the fact that we shall have to consider the *crescent* as the base of attachment of the parietal walls. There is nothing, however, in Lingula or in the Trimerellids from which an homology can here be satisfactorily elicited. While we should be inclined to regard the impression as entirely a muscular scar, we may quote the remarks of the authors above referred to:

"The middle sinus, we have little doubt, has been produced by the umbonal muscle pressing against the post-parietal or posterior wall of the splanchnocœle. It may be suggested that the lateral sinuses have been formed in the same way by other muscles, but as Lingula is not characterized by any similarly situated (at least in the brachial valve*), we prefer the idea that they represent certain viscera; and they may be recesses produced by the pressure of the ovarian lobes against the inner side of the post-lateral walls of the splanchnocœle" (pp. 166, 167).

The validity of this speculation apparently rests, to a great degree, upon the conception of the authors, that the valve under consideration is *not* the pedicle-

in the middle, due, we believe, as in Lingula, to this portion having been forced out by the pedicle; while the crescent in the brachial valve has a pointed crown directed *backward*; now it is this peculiarity that plainly presents itself in Lingulops." Again: "In the Trimerellids, as in Lingula, the pedicle-valve has a short, rudimentary median plate, whereas in their brachial valves this part is well developed and elongated, as it evidently is in Lingulops." Considerable importance is given by the authors to the discussion of the character and function of what they have termed the "semicircular zone," which we regard as the broad inner moiety of the cardinal area, more extremely developed in Monomerella and Rhinobolus. The suggestion is made that it is homologous with that area in the brachial valve of Lingula occupied by the setal band. We have preferred to consider the original valve as the ventral or pedicle-valve, partly on account of the pedicle-groove, which is certainly better defined than it appeared to Messrs Davidson and King, as well as from incontrovertible evidence derived from the opposite valve, which at that time was unknown.

* "In the *pedicle-valve* of *Lingula anatina* the transmedian muscles have their attachment similarly situated. *Were the fossil the same valve, we should have had little hesitation in referring the lateral sinuses to these muscles, notwithstanding their being single on one side and double on the other in Lingula.*"

valve. Furthermore, these considerations require us to regard the *crescent* in LINGULOPS as *not homologous* with the same feature in the Trimerellids, a conclusion which seems unwarranted and *a priori* improbable. This point is, however, maintained by the authors, who, regarding the valve as brachial, suggest that the crescent "was produced by the attachment of the outer muscular cord and associated vessels" of the setal band (p. 166), a statement in direct contravention of that on page 165, viz., "the second" (the "arched fillet" or crescent) "is evidently the equivalent of the crescent characterizing the Trimerellids"; and these authors were the first to demonstrate that this crescent is, essentially, a parietal scar.

The interior of the brachial valve in *Lingulops Whitfieldi* shows the cardinal area and pedicle-groove (as already noticed), and the crescentic ridges essentially as on the opposite valve. The muscular scallops are represented by three depressions, closer together than in the other valve. The most striking and important feature, however, is the platform, sharply developed and showing on its surface faint indications of the median and lateral muscular scars. This organ is even more strongly developed in *L. Norwoodi* and *L. Granti*, but in none of the species is it continued into a longitudinal septum. The vascular sinuses have been observed in *L. Whitfieldi* only, and these appear to be closely similar to those of LINGULA.

With its several linguloid characters well defined, LINGULOPS presents both in its platform and crescent, evidence of a close alliance with the Trimerellids. It is in this genus that appears the first satisfactory evidence of the development of the platform. That this tendency should have advanced farther in the brachial than in the pedicle-valve, is quite in accordance with the relative degree of development seen in opposite valves of the same species in MONOMERELLA and DINOBOLUS. The elevation of the anterior portion of the muscular scars in the pedicle-valve in the earlier species, *L. Whitfieldi* and *L. Norwoodi*, must be regarded as the inception of this tendency toward the elevation of the entire area of muscular insertion, which we find effected in the latest known representative, *L. Granti*.

The shell-substance in Lingulops is exceedingly tenuous and not usually resolvable into layers. The fossils are generally preserved as thin white films, through which the thickened muscular area is plainly visible by its deeper color. Its color alone indicates that its substance is largely if not quite calcareous, differing from Lingula in this respect, but agreeing with Lingulasma and the Trimerellids.

Genus LINGULASMA, Ulrich. 1889.

PLATE II, FIGS. 17-23.

1889. *Lingulasma*, Ulrich. American Geologist, vol. iii. No. 6, p. 383, figs. 5 *a, b, c, d* (p. 378).
Compare *Lingula Canadensis*, Billings, 1862. Palæozoic Fossils, vol. i, p. 114, fig. 95.

Diagnosis. Shell sub-quadrate, linguliform, sub-equivalve; the brachial valve considerably the deeper. Beaks apical, cardinal margins gently sloping to the sides.

Interior of the pedicle-valve with a low concave platform which extends over one-half the length of the shell, and is not hollowed on its anterior wall. The pedicle-area has been largely enclosed within the shell, making a distinct sheath or shelf, beneath which lie the apical portions of the central and lateral muscular scars. Crescentic scars scarcely defined.

The brachial valve is deep, with a high platform of about the same extent as that on the other valve, sloping inward near its anterior margin and continued axially into a strong septum, which reaches nearly to the front of the valve. The anterior walls of the platform are broadly excavated, and close against the base of the septum are hollowed out into short conical cavities. The crescent is strongly developed and sharply pointed backward at its center. Its lateral curves are broad, reaching to the edge of the platform. Directly in front of its central angle lies a short, sharp, median ridge, which disappears near the center of the platform. Lateral and central muscular scars well developed.

Type, *Lingulasma Schucherti*, Ulrich.

Observations. This remarkable form serves as a most important connecting link between the palæozoic Lingulas and the Trimerellids, following, in the

development of its platforms and other interior characters, close upon LINGULOPS, the genus which presents the first deviation, in this direction, from LINGULA. Externally, neither LINGULOPS nor LINGULASMA may be distinguished from LINGULA, but, notwithstanding this exterior linguloid aspect, both exhibit the most positive affiliations with the genus TRIMERELLA. LINGULASMA is represented by a single species, and by the favor of Mr. CHARLES SCHUCHERT we have had at our disposal a number of specimens from the Hudson group at Wilmington and Savannah, Illinois, including the internal cast which has served Mr. ULRICH the purposes of generic diagnosis. These specimens preserve both external and internal features, the cast referred to being in a most favorable condition for study.

In strong contrast to the minuteness of LINGULOPS is the very considerable size of LINGULASMA, and though this difference fails to affect the external linguloid character of the shell, it is to be regarded, in unison with other features, as evidence of progress in the assumption of the characters of the large, thick-shelled Trimerellids. The specimen figured on Plate II would be unusually large for a species of LINGULA.

Primarily, in reference to the determination of the valves of LINGULASMA, we cannot hesitate to regard as the pedicle-valve that which bears the peculiar pedicle-sheath and faint anterior median septum. The brachial valve is then characterized by the strongly elevated septum. Such determination is in harmony with the characters of the respective valves in TRIMERELLA and its closer allies, the stronger septum always appearing in the brachial valve, but it fails to agree, *in this respect*, with LINGULOPS, where the septate valve bears accessory evidence of being the pedicle-valve. We are, however, inclined to regard this septum or low ridge in the pedicle-valve of LINGULOPS as a remnant of its inheritance from LINGULA, rather than a newly assumed Trimerelloid character.

A very remarkable feature in LINGULASMA is the enclosed pedicle-sheath. This takes the form of an arching triangular shelf extending from the apex for about one-eighth the length of the valve. Its surface features are precisely those seen in the cardinal area of TRIMERELLA, viz., a broad

deltidium, with diverging deltidial ridges, outside of which are the areal borders, all marked with successive transverse growth-lines. This sheath appears to have been entirely enclosed by the shell about the umbo, but just at this point all the specimens before us are a little broken, and it is difficult to determine whether or not its apex was extruded for a short distance. The slight gaping of the valves on the cardinal margin indicates that this was probable.

Beneath the shelf thus formed lie the umbonal portions of the progressive muscular scars. The central and lateral scars are strongly developed, passing forward from the pedicle-shelf in three broad ridges, which terminate at the anterior margin of the platform. The crescentic muscular fulcrum is but faintly visible on this valve, though a broad flabellate scar, apparent on each side, probably comprises the terminal and posterior parietal impressions. The platform is comparatively thin and is solid, showing but slight excavation on its anterior wall. From its center a low median ridge extends about half-way over the anterior area of the valve; its margins are excavated by shallow furrows, which unite at the extremity of the ridge and extend to the anterior margin of the valve: on either side of this median furrow is a broad, low elevation, the entire arrangement being equivalent to that seen in the pedicle-valve of *Lingulops Whitfieldi*, though the features are not so conspicuously developed.

In the opposite or brachial valve the crescentic ridge is very strongly developed, its central portion or crown being separate from the lateral portions. From its posterior angle the sides diverge for a short distance, ending abruptly; and from outside and behind these short arms, the ridge again appears, being broader and flatter than before, and sweeping in broad sub-marginal curves to the anterior edge of the platform. The external scars are more distinctly seen than in the pedicle-valve, but they are not very satisfactorily defined. From the crown of the crescent, a low axial septum passes forward to the edge of the platform, dividing the central scar, on either side of which may be seen the lateral impressions. The platform is moderately high and its edge is a little incurved between each ante-lateral angle and the median septum. The latter feature is very strongly developed where it joins

the platform, reaching a height nearly equaling the depth of the valve. The platform itself is solid, except for a slight broad concavity on the posterior wall, which is continued into a minute conical excavation on either side of the base of the septum. No vascular markings are visible on any of the specimens.

The external surface of the shell in *Lingulasma Schucherti* is beautifully sculptured. The concentric growth-lines are very fine, but at intervals bear bead-like granules, which thus become arranged in rows radiating from the apex of the valves. Over the cardinal slopes these granules become transversely elongated and crowded together, usually showing a tendency to merge into the growth-line on which they lie. We have no personal acquaintance with any species congeneric with *Lingulasma Schucherti*, but as suggested by Mr. Ulrich, the *Lingula Canadensis*, of Billings,* from an essentially equivalent fauna (Hudson group of Anticosti) as *L. Schucherti*, may prove to be a Lingulasma. Upon seeking to obtain specimens of the Anticosti species, we have learned from Mr. Whiteaves that Billings' type-specimen, and the only one in the possession of the Canadian Survey, was lost many years ago, and all endeavors to secure specimens from other sources have proved unsuccessful. As far as may be judged from the description and illustration of external features, given both by Mr. Billings and Mr. Davidson (the latter author has identified the species in the Llandeilo formation in Ayrshire, Scotland†) the agreement in size, proportions and surface ornamentation is so close as to suggest almost a specific identity with the Illinois form; and, moreover, Billings' figure indicates the presence of a prominent longitudinal septum. Mr. Ulrich directs attention to similar suggestive resemblances in the species *Lingula granulata*, Phillips, and *L. tenuigranulata*, McCoy,‡ the former from the Llandeilo, the latter from the Bala beds.

The shell substance in Lingulasma is calcareous, with a considerable intermixture of organic matter. Whether these components are arranged separately in the apparent laminæ of the shell, as in Lingula, is not de-

* Palæozoic Foss., vol. i, p. 114, fig. 95.

† See Geol. Mag., 1877, p. 16, and Sil. Suppl., p. 202.

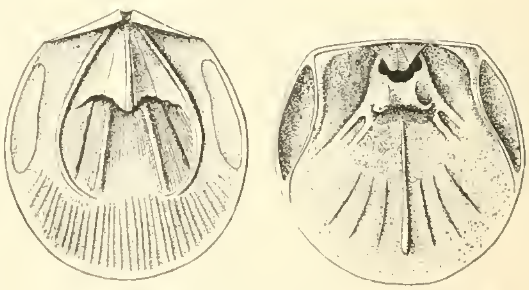
‡ See Davidson Silur. Brach., pl. ii. figs. 15–18 and 9–14.

termined, but we have evidence that the outer or epidermal layer is more largely corneous than those within, and, so far at least, its structure is in harmony with that of LINGULA, as demonstrated by GRATIOLET. But on the other hand, the relative amount of mineral matter in the shell is far in excess of that in LINGULA, and its structure in this respect is wholly in consonance with the other features which establish its transitional position in the line of development from LINGULA to TRIMERELLA. In the latter genus and its associates, the heavy shells have been rarely preserved, or when preserved, their original structure is so essentially altered by dolomitization and crystallization, that it is impossible to gain an accurate conception of their composition. Undoubtedly they were substantially calcareous, with small percentages of organic matter, the latter perhaps relatively increased in the thinner-shelled forms, like DINOBOLUS and some species of MONOMERELLA. The evidence at hand would lead to the presumption that the loss of the organic constituents of the shell, and the increase in calcareous matter, progressed *pari passu* with the assumption of Trimerelloid characters.

GENUS LAKHMINA, ŒHLERT.* 1887.

1885. *Davidsonella*, WAAGEN. Mem. Geol. Surv. India; Palæontologia Indica, Ser. XIII, I, iv, fasc. 5, p. 762.
Not *Davidsonella*, MUNIER-CHALMAS, 1880. Bull. Societé Géologique de France.
1887. *Lakhmina*, ŒHLERT. Fischer's Manuel de Conchyliologie: Brachiopodes, p. 1265.

THIS genus is defined by Dr. WAAGEN in essentially the following terms: General outline more or less linguloid. The ventral valve is the larger and possesses a prominent apex, which is provided, on its lower surface, with a deep furrow for the pedicle. In the interior of the ventral valve, the cardinal margin is somewhat thickened, without forming a distinct area. Below this



Davidsonella (=*Lakhmina*) *linguloides*, after WAAGEN.
FIG 13. Pedicle-valve. FIG. 14. Brachial valve.

* In the preparation of the discussion of this genus, and generally throughout the volume, the term DAVIDSONELLA had been adopted, not being aware that the name had been used by MUNIER-CHALMAS in 1880 for a genus of Liassic brachiopods allied to THECIDIUM. We are therefore reluctantly compelled to adopt the term LAKHMINA, proposed by ŒHLERT; though it must not be forgotten that it is to Dr. WAAGEN we are indebted for the careful analysis of the genus.

extends a not very large triangular platform, which is vaulted, and supported by a median partition not extending beyond its anterior margin. This platform is enclosed by low, rounded ridges which originate near the pedicle-furrow; its surface is flattened medially, but concave on the sides. Of muscular impressions nothing can be observed.* In the dorsal valve the cardinal margin is but little thickened and slightly curved. In the middle it bears a thickened process, which is directed somewhat upward and inward, extending partly into the apical cavity of the other valve. From beneath this process, a short thickened platform takes its origin; it is not even on the upper surface, but to all appearances spirally rolled; it is concave in the middle and bears on both sides elevated crests with sloping lateral faces; its anterior margin is curved inward, and the whole platform seems to be excavated below. From its sides diverge two bifurcating ridges, and a median septum extends nearly to the anterior margin. Near the lateral margins two sharply defined spaces are enclosed by narrow ridges. The interiors of both valves are marked with radiating striæ. Shells small; shell substance very thin.

Type, *Lakhmina linguloides*, Waagen, *op. cit.*, p. 764, pl. lxxxv, figs. 3–6.

In the present state of our knowledge, this genus must be regarded as the earliest representative of the Trimerelloid brachiopods. Its occurrence is in the so-called "Obolus-beds" of the Salt-Range of India, in association with several other peculiar inarticulate brachiopodous genera, *e. g.*, NEOBOLUS, DISCINOLEPIS, SCHIZOPHOLIS, etc. At the date of the description of these genera (1885), this formation was considered as conformable with the overlying Carboniferous and Permian rocks of the "Productus-limestone" series, and was, therefore, referred to the Carboniferous age. The fauna bears upon its face a primordial expression, and, before the detailed study of the brachiopods, was regarded by Mr. WYNNE, Dr. STOLICZKA and Dr. WAAGEN himself, as of primordial age. But the subsequent determination by Mr. R. D. OLDHAM, of great unconformity

* Dr. WAAGEN does not consider the lateral impressions seen on his figure (which, he says, represent these features too sharply) as of muscular origin, but as the deepened spaces outside the crescent. They certainly are similar in position and extent to the terminal scars as developed in some species of MONOMERELLA and TRIMERELLA.

in the adjacent beds, and the more recent discovery by Dr. WARTH, of trilobites in the "Obolus-beds," which have been referred by WAAGEN to the genera *Conocephalites* and *Olenus* (?), point conclusively to such an age.* Nevertheless, some of the brachiopod genera show certain details of structure which indicate an important progress from the types exemplified in their nearest primordial allies; for example, the great cardinal process in NEOBOLUS, the hinge-line in CARDINOCRANIA, and thus, also, in LAKHMINA, the cardinal process in the brachial valve is developed to a greater degree than has been observed among the later Trimerellids. The peculiar modification of the platform in this valve is also an important character. The advance apparent in the development of this feature in the brachial valve of LINGULOPS and LINGULASMA, over that of the opposite valve, is here seen in the strongly elevated, though short, deeply enrolled posterior plate. The single species of this genus is quite small, and some of its internal characters are not well understood.

THE GENERA TRIMERELLA, DINOBOLUS, MONOMERELLA, and RHINOBOLUS, show a remarkable uniformity in their broadest characters, which may be expressed by the following analysis of the *Family* TRIMERELLIDÆ, *Davidson* and *King*:

SHELLS essentially calcareous, usually thick and heavy. Umbo of the pedicle-valve generally high, solid or hollow: when the latter, double or triple-chambered. Cardinal area well developed; hinge-line inarticulate or with rudimentary teeth (?); supported in the pedicle-valve by a vertical axial wall or buttress. Each valve bears, in its post-median portion, a more or less conspicuously developed platform, which may be solid or hollow; when the latter, it is double-chambered; from its anterior end extends a vertical septum, which is usually larger in the brachial, than in the pedicle-valve. A narrow crescentic impression lies just within the hinge-line, terminating within the lateral margins in broad muscular scars. The surface of the platform bears three or four pairs of similar scars. The pallial sinuses make a broad curve over the anterior area of each valve.

This group has been made the subject of an exhaustive analysis by Drs.

* *See* Note on the Discovery of Trilobites by Dr. H. WARTH, in the Neobolus-beds of the Salt-Range; by the Director, Geological Survey of India: Records Geol. Surv. India, vol. xxii, pt. 3, p. 153. 1889.

THOMAS DAVIDSON and WILLIAM KING,* and though fifteen years have now elapsed since the date of its publication, later observations have hitherto added comparatively very little to the results achieved by these eminent investigators, and have taken nothing away from their value. The scope of this work included not only a detailed discussion of the characters and relations of the family, involving the establishment of an elaborate anatomical nomenclature, but also descriptions of all the species then known to represent the three genera, TRIMERELLA, MONOMERELLA and DINOBOLUS. This nomenclature we have adopted without essential modification, and its application is sufficiently explained by the accompanying outlines, showing the internal features of TRIMERELLA, taken from the same work. We have also accorded recognition to the generic term RHINOBOLUS, which was made a synonym for TRIMERELLA in that work, but we now possess a considerably increased knowledge of this form, and have elsewhere quoted a subsequently expressed opinion of Mr. DAVIDSON's, abandoning his earlier views on the value of this

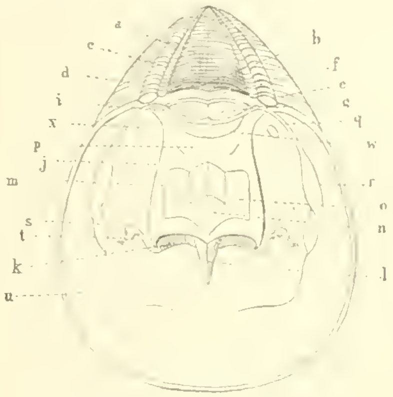


FIG. 15. Pedicle-valve of *Trimerella*.

FIG. 16. Brachial valve of *Trimerella*

After DAVIDSON and KING.

a, deltidium.
b, deltidial slope.
c, deltidial ridges.
d, areal borders.
e, cardinal callosities.
f, cardinal facet.
g, lozenge.
h, cardinal buttress
i, umbonal chambers.
j, platform.
k, platform vaults.
l, median plate.
m, median scars
n, anterior scars.
o, lateral scars.
p, post-median scars.
q, crown } crescent.
r, side } crescent.
s, end } crescent.
t, transverse scars.
u, archlet (vascular sinuses).
w, sub-cardinal scars.
x, umbo-lateral scars.

e, cardinal sockets.
j, platform.
k, platform vaults.
l, median plate.
m, median scars
n, anterior scars.
o, lateral scars.
p, post median scars.
q, crown } crescent.
r, side } crescent.
s, end } crescent.
t, transverse scars.
u, archlet (vascular sinuses).
v, cardinal scars.
w, sub-cardinal scars.

* On the Trimerellidæ, a Palæozoic Family of the Palliobranchs or Brachiopoda. By THOMAS DAVIDSON, Esq., F. R. S., F. G. S., etc., and Professor WILLIAM KING, Sc. D. Honoris Causa, Queen's University in Ireland: Quart. Journ. Geol. Soc., vol. xxx, pp. 124–173, pls. xii–xix. 1874.

genus. In an appendix to their paper, the authors mentioned discussed the character of the genus LINGULOPS, then known only from the interior of a single valve, and pointed out its affiliations with the Trimerellids. Of this genus also our knowledge has greatly progressed, and we have now not only an accurate understanding of the interiors of both valves of the type-species, *L. Whitfieldi*, but also of two other species, *L. Norwoodi* and *L. Granti*. These have furnished indisputable evidence of Trimerelloid characters, and show the first deviation in this direction from the typical LINGULA. Added to this is the genus LINGULASMA, recently described by Mr. E. O. ULRICH, which presents another interesting and important link in the development of this family. These latter genera (and we have elsewhere adverted to the same subject more at length) are neither true Trimerellidæ under the foregoing definition of this group, nor can they be properly included under the Lingulidæ, except as a matter of convenience in classification, and we here meet, as we often do in the study of the inarticulate brachiopods, an emphatic protest against the unnatural rigidity of any scheme of classification, requiring the alignment upon the same plane, of forms which may be, in various directions, successive and gradational.

The anatomical features of these shells calling for especial attention are (1) the platform, (2) the umbonal chambers, (3) the muscular scars. The first two are treated in reference to their development and functions in another place (see page 46). The last is most remarkable for the striking specialization of the so-called "crescent," a sub-marginal, cardinal impression, skirting the posterior area of the shell in both valves and terminating in, or just enclosing at about the middle of the sides, a prominent, sometimes compound scar. This is believed to be the impression of a strong muscular post-parietal wall, its position being quite analogous to the same feature in LINGULA. The lateral and terminal impressions are undoubted analogues of those occupying similar positions in *L. anatina* (*i*, *j*, *l*, in the pedicle-valve; *l*, *i*, *k*, in the brachial), and though evidently compound, it has been hitherto impossible to resolve them into more than two distinct pairs of scars. The median impression, *i. e.*, that covering the surface of the platform, is readily resolvable into central, lateral,

and, usually, anterior scars; the post-median impression, indicated upon DAVIDSON and KING'S figure above given, and considered by these authors as the marks of the genitalia, is, usually, extremely indistinct. Just within the cardinal margin are seen, more clearly in RHINOBOLUS than elsewhere, two small, distinct scars (umbo-laterals), the function and analogues of which are not understood.

GENUS TRIMERELLA, BILLINGS. 1862.

PLATE IV A, FIGS. 1-10, AND PLATE IV B, FIGS. 1-6.

1862. *Trimerella*, BILLINGS. Palæozoic Fossils, vol. i, p. 166.
1867. *Trimerella*, LINDSTRÖM. Öfvers. af Kongl. Vetenskaps-Akad. Förhandl. No. 5, p. 253, pl. xxi.
1868. *Trimerella*. LINDSTRÖM. Geological Magazine, vol. v, p. 441.
1870. *Gotlandia, Trimerella*, DALL. American Journal of Conchology, vol. ii, pt. 2, p. 160.
1871. *Trimerella*, MEEK. American Journal of Science, Third Ser., vol. i, p. 305.
1871. *Trimerella*, DALL. American Journal of Conchology, vol. vii, pt. 2, p. 83.
1872. *Trimerella*, DAVIDSON and KING. Report Brighton Meeting Brit. Assoc.
1873. *Trimerella*, HALL. Twenty-third Rept. N. Y. State Cab. Nat. Hist., pl. xiii, figs. 11-16.
1873. *Trimerella*, MEEK. Geology of Ohio; Palæontology, vol. i, pp. 182, 183, pl. xvi.
1874. *Trimerella*, DAVIDSON and KING. Quart. Journ. Geol. Soc., vol. xxx, p. 143, *et seq.*
1875. *Trimerella*, NICHOLSON. Rept. Palæont. Prov. Ontario, pp. 67, 68, figs. 36, 37.

DIAGNOSIS. Shell thick; outline elongate-ovate.

Pedicle-valve with an erect and straight umbo, which is usually solid for the greater part of its length, but double-chambered toward its base; cardinal area very prominent; deltidium broad; deltidial ridges more or less conspicuous; deltidial callosities slightly developed; cardinal slope well defined. Crescent sharply incised over its summit, but faint toward the sides, where it is connected with the broad lateral and terminal scars which are not so distinctly outlined as in the allied genera. Platform long, narrow, and strongly developed; platform-vaults tubular, the dividing wall being continued as a short septum in front of the platform. Muscular scars of the platform usually extremely faint, but under favorable preservation divisible into median and lateral components. Pallial sinuses faint.

Brachial valve with a marginal umbo, which is much thickened in some instances, without producing a cardinal area, though making a prominent apophysis which is extended against the cardinal slope of the opposite valve.

Crescent as in the other valve. Platform higher than in the pedicle-valve, its vaults extending scarcely so far backward. Anterior median septum long, often reaching almost to the margin. Muscular and pallial impressions faint.

Type, *Trimerella grandis*, Billings.

Observations. The species of this genus are subject to some interesting variations, though, in the development of certain features within the limitations of a given species, such great differences are not as noticeable here as in Monomerella and Dinobolus. The relative size of the great cardinal area appears to be a permanent character. A tendency toward the subdivision of the umbonal cavity by a vertical septum (cardinal buttress) is apparent in all species, and constitutes an approach to the large umbonal chambers in Monomerella. The great development of the platforms necessitates the abbreviation of the umbonal chambers, while, accompanying the obsolescence of the platforms in Monomerella, is a resultant increase in the size of these chambers.* In the brachial valve the umbo is incurved, and just beneath, or within it, is sometimes developed a strong process, grooved on its outer surface. This feature is seen in *T. Ohioensis*, Meek and *T. Lindstrœmi*, Dall. Messrs. Lindström, Davidson and King, and Dall have been disposed to regard this as a cardinal process, fitted like a tooth into an excavation at the base of the deltidium of the opposite valve. The evidence of such a process affording attachment for muscles opening the valves is generally wanting among the other genera, and other species of this genus: and if this process served such a function, we should expect to find correspondingly large and deep muscular scars upon the platform of the pedicle-valve. Our evidence on this point is rather negative, though through-

* The Gotland species, *T. Lindstrœmi*, Dall, possesses a peculiar umbonal character. The small lateral umbonal chambers are forced wide apart by the development of a median, undivided cavity, which makes the umbo hollow for its entire length. This cavity is represented in the figures given by Lindström, Davidson and King, as opening at the hinge-line or posterior margin of the platform. No similar structure, or any tendency to its formation, has been observed in any other species; on the contrary, the strong cardinal buttress usually occupies this median position. Several specimens of the pedicle-valve of this species, after having the matrix carefully removed by means of caustic potash, give no evidence whatever of this opening, the shell being perfectly continuous from the platform to the deltidium, and we are led to suggest that the external opening of this cavity, so out of harmony with the typical characters of the genus, may be due to fortuitous causes. The cardinal buttress, however, is replaced by a remarkably broad and deep excavation.

out the Trimerellas, the scars are much less sharply defined than in the other genera of the family. Thus, there may be no sufficient reason to doubt that when this apophysis is developed, it is analogous to the cardinal process in the articulates; and we have confirmatory evidence of this function of the process in its great development in LAKHMINA.

The platforms in the Trimerellas have usually about the same relative degree of development, being generally slightly larger in the brachial than in the pedicle-valve, and vaulted for almost if not quite their entire length, except in the species *T. Billingsi*, Dall, where they are solid for about two-thirds their length. This species again indicates the tendency toward MONOMERELLA in the gradual obliteration of these platform-vaults. The usual faintness of all the muscular impressions must be due, in an important degree, to the condition of preservation of the fossils. The shells were among the most ponderous of all brachiopods, and the muscles to wield them must have been of great size and have produced strong scars. The American specimens of TRIMERELLA are almost invariably internal casts in dolomitic limestones, and the removal of the shell-substance left great space for the operation of crystallizing forces which would go far toward the obliteration of these impressions. An interesting feature is the not infrequent irregular development in the vaults of the platform, one being sometimes shorter or broader than the other. A tendency to lateral asymmetry in the growth of the umbonal portions of the shell is sometimes seen, resulting in a deflection of the beak and platform to one side. (See Plate IV A, fig, 3.)

In some species, noticeably in *T. acuminata*, Billings, the platform of the pedicle-valve bears a deep median furrow, beginning at the base of the cardinal buttress and narrowing anteriorly. This feature is developed, to a greater or less degree, in most of the species, and may represent the position of the ovaries (*post-median scar*, DAVIDSON and KING).

TRIMERELLA is represented in American faunas by five species: *T. grandis* and *T. acuminata*, Billings; *T. Billingsi*, Dall; *T. Dalli*, Davidson and King; *T. Ohioensis*, Meek. All these are known to occur in the Guelph limestone of the

Province of Ontario: *T. Ohioensis*. *T. grandis* and *T. acuminata* are known in the Niagara dolomites of Ohio, and *T. acuminata* from Port Byron, Illinois, but, strangely enough, we have no knowledge of the occurrence of any species of the genus in association with the great numbers of Monomerella and Dinobolus in the rocks of the same age in Wisconsin; *T. acuminata* has been found by Lindstrom in association with *T. Lindstrœmi*, on the islands of Gotland and Faro; *T. Wisbyensis*, Davidson and King, is a little known species from the former island. The age of the Swedish specimens is that of the Aymestry and Wenlock limestone of Great Britain.

Genus DINOBOLUS, Hall. 1871.

PLATE IV B, FIGS 13-24.

1850. *Lingula*, Rouault. Bull. Soc. Géol. de France, 2nd ser., vol. vii, p. 128.
1853. *Obolus*, Davidson. Introduction to British Fossil Brachiopoda, p. 58.
1858. *Obolus*, Billings. Rept. Geological Survey Canada, p. 189.
1859. *Obolus*, Salter. Murchison's Siluria, Second Ed., p. 543.
1860. *Obolus*, Lindström. Öfvers. af Kong. Vetenskaps-Akad. Förhandl., p. 375.
1862. (*Conradia*), Hall, MS. See Davidson, Quart. Journ. Geol. Soc., vol. xxx, p. 159, foot note. 1874.
1863. *Lingula*, Salter. Quarterly Journal Geological Society, vol. xx, p. 294, pl. xvii, figs. 2, 3, 6.
1866. *Lingula*, Davidson. British Silurian Brachiopoda, p. 11, pl. i, figs. 21-26.
1866. *Obolus*, Davidson. British Silurian Brachiopoda, p. 59.
1868. *Obolus*, Hall. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 368, and 1870, *idem.*, Revised Edition, p. 375.
1868. *Obolus* (*Trimerella?*), Meek and Worthen. Geol. Survey Illinois, vol. iii, p. 351, pl. v, fig. 7.
1869. *Lingula*, Davidson. Quarterly Journal Geological Society, vol. xxvi, pl. iv, fig. 3.
1871. *Dinobolus*, Hall. Notes on some New or Imperfectly known Forms among the Brachiopoda, p. 4, March; in advance of Twenty-third Rept. N. Y. State Cab. Nat. Hist. 1873.
1871. *Obolellina* (*partim*), Billings. Canadian Naturalist, p. 222. December.
1871. *Trimerella* (*partim*). Dall. American Journal of Conchology, vol. vii, pt. 2, p. 83.
1872. *Obolellina* (*partim*), Billings. Canad. Nat., p. 330, Dec.: Amer. Journ. Sci., vol. iii, p. 359.
1872. (*Conradia*). Hall. American Journal of Science, Third Ser., vol. iv, p. 107; and, 1873, Twenty-third Rept. N. Y. State Cab. Nat. Hist., p. 250.
1872. *Dinobolus*, Davidson and King. Rept. Brighton Meeting Brit. Association.
1872. *Dinobolus*, Davidson and King. Geol. Magazine, vol. ix; and Ann. and Mag. Nat. Hist., vol. x.
1874. *Dinobolus*, Davidson and King. Quart. Journ. Geological Society, vol. xxx, p. 159.
1875. *Dinobolus*, Hall and Whitfield. Geol. Surv. Ohio; Palæont., vol. ii, p. 130, pl. vii, figs. 3, 4.
1875. *Dinobolus*, Nicholson. Palæontology Province of Ontario, p. 18, fig. 6 *a*; p. 68, fig. 38.
1879. *Trematis*, Barrande. Système Silur. Bohême, pl. 94, fig. vi; pl. 95, fig. x.
1880. *Dinobolus*, Davidson. Geological Magazine, new ser., vol. vii, p. 340, pl. x, figs. 1-6.
1881. *Dinobolus*, Davidson. Brachiopoda of the Budleigh-Salterton Pebble-bed, p. 365, pl. xl, figs. 22, 23.
1882. *Dinobolus*, Whitfield. Geology of Wisconsin, vol. iv, p. 347, pl. xxvii, figs. 8-10.

Diagnosis. Shell sub-circular; valves convex, thick.

Pedicle-valve with an acute and slender beak; cardinal area triangular, more or less elevated, but never so high as in Trimerella or Monomerella. Cardinal margins sometimes of considerable width. Umbo generally solid, but often slightly excavated on either side of a simple or double vertical wall, or buttress. Crescent distinct, its apex making a retral angle; narrow over the crown, widening into the great terminal scars. Platform low, broadly V-shaped on its anterior margin, which usually lies at about the middle of the valve; generally, with very short, flattened, abruptly conical vaults, but occasionally these vaults are of the same relative length as in Trimerella, though much shallower. Central and lateral muscular scars on the platform usually distinct, the former lying in a depressed median groove, the latter occupying the greater portion of the surface. Subcardinal and anterior scars rarely discernible. Anterior median septum scarcely developed. Pallial sinuses faint.

Brachial valve with the beak submarginal, inconspicuous and usually not discernible; hinge-area very narrow. Crescent very strong, especially over the crown, where it makes a sharp posterior angle beneath the beak, sloping thence very gently, being almost transverse for about the width of the platform, then bending quite abruptly and being slightly interrupted at the position of the terminal scars, which are more approximate than in the opposite valve. In the type-species, the crown of the crescent, as usually developed, is a sharply incised, narrow furrow, bounded within by a broad elevation sloping to the position of the subcardinal scar, but not infrequently it is a ridge, bounded in front and behind by a deep furrow. This difference in appearance is due to the varying development of the anterior furrow, which is sometimes quite suppressed. Platform narrower and more sharply V-shaped than in the opposite valve; vaults usually very short and abruptly conical. Lateral and central scars on the platform conspicuous, the latter lying in a deep median furrow, at the front end of which are sometimes seen the faint anterior scars. In the line of this furrow, directly in front of the apex of the crescent, lies the deep impression of the subcardinal muscle, which makes a prominent feature on the cast, suggestive of the filling of the umbonal cavity, which it

may be to some extent, although the apex of the beak is actually quite remote from it. From this point to the center of the crescent extends a short furrow, on either side of which lies the impression of an accessory scar, probably correlated to the umbo-lateral scars of RHINOBOLUS and TRIMERELLA. Pallial sinuses more or less distinct. Median septum low, but stronger than in the opposite valve.

Type, *Dinobolus Conradi*, Hall.

OBSERVATIONS. Such considerable variations in certain features occur within the limitations of a single species of this genus, that we are disposed to regard the recognition of the eight or nine species, which have been described, of somewhat questionable authenticity. We have before us a large number of finely preserved specimens of the type-species, *D. Conradi*, from Le Claire, Iowa; Cedarburg, Wisconsin; Hawthorne and Port Byron, Illinois; all of which indicate that variations are to be expected (1) in the development of the deltidium, which though usually quite low, may attain a very considerable elevation; (2) in the size of the platform-vaults, which in both valves, are usually no more than a broad, general excavation of the anterior walls of the platform, narrowing abruptly into minute conical cavities, though in the pedicle-valve they occasionally are long and tubular, and, in both valves, there is sometimes evidence of a tendency to form two or even three chambers in each vault; this may be regarded as an abnormality, but it occurs in at least six instances in the examples at hand: (3) in the position of the platform, its apex usually lying at about the center of the valve, but sometimes situated more posteriorly.

Upon comparing the features of the interior of *D. Conradi* with the best known of the other species, *D. Davidsoni*, Salter, we do not observe features which lead to a satisfactory specific distinction. From the figures given by DAVIDSON and KING,* it appears that this species is also susceptible of variation, for example, in the development of the median scar in the pedicle-valve, which may be either a ridge or a furrow. In the description and figures of

* *Loc. cit.*, pl. xviii, figs. 6–11.

Dinobolus Schmidti, Davidson and King, from Esthonia, Russia, as given by these authors, it is impossible to cite specific differences from *D. Conradi*; *D. Canadensis*, and *D. magnificus*, Billings, are known only from their exterior; *D. Woodwardi*, Salter, is imperfectly understood, while *D. transversus*, Salter, *D. parvus*, Whitfield, and *D. Bohemicus*, Barrande, appear to be well defined species.

The close relationship of DINOBOLUS to MONOMERELLA is apparent both in the slight development of the umbonal cavities in the pedicle-valve, and in the general aspect of the interior of the brachial valve, the shape of its platform and development of its muscular scars. The differences, however, are of permanent value. No true platform-vaults are formed in either valve of MONOMERELLA, merely a broad, general excavation of the anterior walls of the platform; moreover, the crescent in this genus never attains the strong and peculiar development seen in DINOBOLUS, but is more of the nature of that in TRIMERELLA. The approach to TRIMERELLA indicated by the long vaults occasionally seen in DINOBOLUS, has been referred to, but in no instance among the Trimerellas or Monomerellas has there been observed any tendency to a duplication of these vaults, as in DINOBOLUS. In some respects, therefore, DINOBOLUS stands as the connecting link of these two genera; or, as it was the first of the genera to appear in palæozoic faunas, it may be naturally considered the more comprehensive type of TRIMERELLA, MONOMERELLA and RHINOBOLUS, from which these latter may have derived many features by easy stages of evolution.

DINOBOLUS makes its first appearance in the Lower Silurian,* *D. Brimonti*, Rouault,† being from the Budleigh-Salterton pebbles, and various localities in Brittany, of the age of the lower Llandeilo, or the Grès Armoricain; *D. magnificus*, Billings, and *D. Canadensis*, Billings, from the Black River limestone

* Mr. DAVIDSON described a species, *Dinobolus? Hicksi*, from the Upper Arenig of St. David's (Quart. Journ. Geol. Soc., vol. xxxi, p. 188, pl. x, fig. 6. 1875; and British Silurian Brach. Suppl., p. 212, pl. xvi, fig. 19. 1883), but the characters of the single specimen are so obscure as to render this reference exceedingly questionable.

† DAVIDSON. Brachiopoda of the Budleigh-Salterton Pebble-bed, p. 365, figs. 1, 2 (p. 366), pl. xl, figs. 22, 23. 1881.

(Trenton): *D. parvus*, Whitfield, from the Galena limestone (Trenton) at Whitewater, Wisconsin; *D. Schmidti*, Davidson and King, is stated to be from the Lyckholmer Schichten of Esthonia, Russia, considered to be nearly the equivalent of the Caradoc and Trenton; the greatest individual development of the genus, however, is in the Niagara fauna and its equivalents, *D. Conradi* being the American representative of *D. Davidsoni*, Salter, a Wenlock species occurring near Dudley and elsewhere in England, county Kerry, Ireland, and on the Island of Gotland: *D. transversus* and *D. Woodwardi*, Salter, are from the same horizon, and the *Trematis Bohemica*, Barrande (= *Dinobolus*), is from an equivalent fauna (Etage E–e_2).

Genus MONOMERELLA, Billings. 1871.

PLATE IV c, FIGS. 1-18; AND PLATE IV d, FIGS. 1-15.

1871. *Monomerella*, BILLINGS. Canadian Naturalist, vol. vi, p. 220.
1872. *Monomerella*, DAVIDSON and KING. Ann. and Mag. Nat. Hist.; Geol. Mag.; Report Brighton Meeting of British Association.
1874. *Monomerella*, DAVIDSON and KING. Quarterly Journal Geological Society, vol. xxx, p. 155.
1875. *Monomerella*, NICHOLSON. Rept. Palæontology of the Province of Ontario, p. 68.
1875. *Monomerella*, HALL and WHITFIELD. Geol. Surv. Ohio; Palæont., vol. ii, p. 131, pl. vii, figs. 1, 2.
1884. *Monomerella*, WHITEAVES. Palæozoic Fossils, vol. iii, pl. 1, pp. 5, 6.

DIAGNOSIS. Shell usually thick, but in some cases quite thin; outline varying from elongate-ovate to subcircular. Surfaces of contact of the valves sometimes conspicuously broad.

Pedicle-valve with a more or less elevated umbo, which may vary in height in a given species, in the type-species being high, as in TRIMERELLA; umbonal cavity divided into two chambers by a longitudinal septum. Cardinal area large; deltidial ridges and deltidial callosities not always distinctly developed; cardinal slope usually well defined, merging anteriorly into the cardinal buttress, or umbonal septum; in some species this slope, or subtriangular area, is longitudinally divided by a furrow. The crescent is sharply impressed over the cardinal slope; terminal scars broad and distinct. Platform more or less developed; divided by the cardinal buttress, which extends nearly or quite its entire length. Muscular impression on the platform very large, covering the

entire surface, but rarely resolvable into separate scars. Anterior septum indistinct, usually imperceptible. Pallial sinuses sometimes clearly defined.

Brachial valve with the umbo seldom conspicuously developed, the umbonal cavity being usually simple and deep, but sometimes filled by a deposition of shelly matter. Crescent sharply impressed over the narrow cardinal slope, and produced into broad, indistinct, composite terminal scars. Platform usually well developed and broadly excavate on its anterior walls, but sometimes scarcely discernible. Anterior and lateral scars sharply defined, giving a tripartite appearance to the platform. Anterior septum more strongly developed than in the opposite valve.

Type, *Monomerella prisca*, Billings.

OBSERVATIONS. The very rich material that has been before us in the study of this genus, has added a number of interesting and previously unknown forms, and the variations from the type-species shown by these, has made it necessary to modify in some respects the diagnosis of MONOMERELLA, as given by DAVIDSON and KING. At the date of their work but four species were known, and the four additional species, which, for convenience in discussing the genus, are described in the supplement to this volume, present some important deviations from the type-form, and necessarily broaden the scope of the genus. Mr. BILLINGS' species, *Monomerella prisca* and *M. orbicularis*, from the Guelph limestone at Hespeler, Canada, were first illustrated by the English writers, who also added two new species, *M. Walmstedti*, from the Aymestry limestone of Gotland, and *M. Lindstrœmi*, from the Wenlock near Wisby. The former of these Gotland species is very closely allied to *M. prisca*. Indeed, we are compelled to include under this latter name, American forms which vary so considerably in the elevation of the cardinal area, size of the umbonal chambers of the pedicle-valve, and the depth of the umbonal cavity in the brachial valve, that with this broader conception of the specific characters of *M. prisca*, it would be easy to consider *M. Walmstedti* as conspecific. The specimens of *M. prisca*, from the dolomites of the Niagara group, at the Rising Sun quarries, Wood county, Ohio; Hawthorne, Port Byron and Cicero, Illinois; and near

Cedarburg and Grafton, Wisconsin, show not only the high area and deep chambers of the Canadian types, but deviations therefrom, which, if found in specimens unassociated with the intermediate forms, might be regarded as of distinct specific value. We have, on a preceding page, called attention to essentially similar variations in the species *Dinobolus Conradi*.

The cardinal area of the pedicle-valve in *M. prisca* is always erect, and its subdivisions are sharply defined; a broad, usually convex though depressed deltidium is bounded by elevated deltidial ridges merging into the areal borders, and has the deltidial callosities or articulating (?) apophyses more strongly developed than elsewhere noticed among the Trimerellids. On the other hand, in *M. Ortoni*, the cardinal area, equally broad and high, is gently incurved, as in RHINOBOLUS, and is transversely striated, but has only very faint evidence of longitudinal subdivision In *M. Greenii* and *M. ovata*, this area is low, smooth, and not subdivided, but is continued about the margins into a broad surface of contact with the other valve. In the brachial valve of *M. prisca* and *M. Kingi* the cardinal area is slightly if at all developed, the beak being marginal; while, in *M. Greenii*, it is somewhat elevated, and, in *M. Egani*, very prominently developed.

The development of the umbonal chambers depends essentially on the height of the umbo, and the degree of its thickening; in *M. prisca* always extending above the hinge-line, in *M. ovata* and *M. Kingi* they reach to the hinge, and, in *M. Greenii*, rarely appear to extend so far. The umbonal cavity of the brachial valve is subject to even greater variation, but this is more largely an individual than a specific divergence. In the thin-shelled species, *M. Greenii*, this cavity is invariably deep, but in *M. prisca* it appears to be frequently thickened by internal deposition. This feature is also seen in *M. Kingi*, and in the single valve representing the species, *M. Egani*, we have an example of this umbonal thickening carried to an extreme.

The platform, never so strongly developed as in TRIMERELLA, nor furnished with vaults, is usually a conspicuous feature, but in *M. Greenii* it is almost obsolete, its position being evident only from the slightly thickened muscular scars.

Generally these muscular scars are sharply defined. Those on the platform of the pedicle-valve indicate very large organs, but in *M. prisca* we have been unable to resolve them as DAVIDSON and KING have done. In *M. Greenii*, the lateral scars are clearly outlined and limited to a comparatively small surface. Their small size may be largely due to the fact that the valves of this species were comparatively light; their position, close together on either side of the median septum, is very suggestive of the muscular arrangement in SCHIZOCRANIA In *M. Ortoni* there appears a prominent anterior scar with fainter laterals, bordered in front by narrow converging furrows.

On the brachial platform, the subdivision of the muscular impression is always strong, producing a trilobate appearance; sometimes the shell is so preserved as to show the long progressive track of the laterals and the centrals, at others, the older portions of the scars are covered by an organic deposit limiting the impressions to the area last covered by the muscular bands.

In one species, *M. Ortoni*, the impressions of the pallial vessels. both primary and secondary, are very distinct, and this is the only instance in which the ramifications from the main vascular trunks have been observed in this group.

MONOMERELLA is readily distinguished from the allied genera by its two umbonal chambers and low, unvaulted platforms. In the brachial valves of this genus, and of DINOBOLUS and RHINOBOLUS, the similarity in internal features is very close, and care is required in the generic determination. In DINOBOLUS the platforms are always vaulted, to some degree, by conical cavities, and not merely broadly excavated on the anterior walls; the umbonal cavity is a small, acute depression, never filled by testaceous deposit; the crescent is always broad, with abrupt lateral angles. RHINOBOLUS possesses a very short platform, strongly elevated at its anterior margin, and sloping abruptly backward, but there is no evidence of its general suppression as sometimes occurs in MONOMERELLA.

Species of this genus, like those of TRIMERELLA, are very limited in faunal range. The Canadian examples are all from the Guelph limestones of the Province of Ontario; those from the States of Ohio, Illinois and Wisconsin are from dolomites usually referred to the age of the Niagara of New York:

but probably serving as a faunal equivalent of the Niagara and Guelph formations. No species are known in Great Britain, those from the Island of Gotland, and from Livonia, Russia, are from faunas corresponding to that of the Niagara and Wenlock.

Genus RHINOBOLUS, Hall. 1871.

PLATE IV B, FIGS. 7-12.

? 1862. *Obolus*, Billings. Palæozoic Fossils, vol. i, p. 168, fig. 151.
1871. *Trimerella*, Dall. American Journal of Conchology, vol. vii, p. 83.
1871. *Rhynobolus*, Hall. Advance sheets (March) Twenty-third Rept. N. Y. State Cab. Nat. Hist., p. 247, pl. xii, fig. 10. 1873.
[? 1871. *Obolellina*, Billings. Canadian Naturalist, vol. vi, New Series, p. 220 (December).
1872. *Dinobolus*, Davidson and King. Report Brighton Meeting of British Association.
1874. *Trimerella* (?), Davidson and King. Quart. Journ. Geological Society, vol. xxx, p. 151, pl. xviii, fig. 13; pl. xix, figs. 4, 4*a*.
[? 1881. *Rhynobolus*, Whiteaves. Palæozoic Fossils, vol. iii, pt. 1, p. 7, pl. ii, fig. 1*a*; pl. viii, figs. 3, 3*a*.

Diagnosis. General form of the shell as in Trimerella.

Pedicle-valve, in the typical species, with an elevated, solid beak, having a broad and high deltidium, divided into a relatively narrow central area (which may be concave or convex), and broad deltidial ridges. Crescent and terminal scars as in Trimerella. Umbo-lateral scars sharply defined. Platform very low and incompletely developed, consisting of a broadly V-shaped elevation, with a raised anterior margin, and surface sloping abruptly backward to, or even below the general curvature of the internal surface. A faint longitudinal septum extends forward from the platform.

Brachial valve with low, sub-marginal, slightly curved apex, and short deltidium. Crescent conspicuously developed. Platform as in the opposite valve, with the addition of a central scar, which gives the entire area a tripartite appearance. Median septum faint.

Type, "*Rhynobolus* —— ?" Hall. (1871, *loc. cit.*, pl. xii, fig. 10.)

Observations. The description of the genus Rhinobolus (erroneously printed Rhynobolus) was based upon the interior of a pedicle-valve, characterized as in the foregoing diagnosis. At the time of the publication of the generic term, this valve had not been positively identified with the *Obolus Galtensis* of Billings

(a species then known only from an imperfect interior of the brachial valve), as was subsequently done by DAVIDSON and KING, DALL, and WHITEAVES, but it was simply suggested that BILLINGS' species might prove a representative of the same genus.

Mr. WHITEAVES has given (*loc. cit.*) figures of *Rhinobolus Galtensis*, which represent not only a brachial valve in entire agreement with the figures published by BILLINGS, DAVIDSON and KING, and with specimens in the possession of the New York State Museum, but also a pedicle-valve, which is referred by him to the same species, but which does not at all agree with the original specimen of RHINOBOLUS. It is, on the contrary, of about the same outline as the brachial valve, with a low, incurved umbo and a very broad margin of contact, much like that seen in the species *Monomerella ovata* and *M. Greenii*. Should this prove to be the pedicle-valve of the species, a doubt might fairly arise as to the propriety of including it under the genus RHINOBOLUS. Mr. WHITEAVES' specimens are from Hespeler and Durham, Ontario, and all retain the shell, but it does not appear that the valves have been found in connection. The original specimen of RHINOBOLUS was from Galt, and before us is a very perfect brachial valve from Elora, in exact agreement with those referred to BILLINGS' species, and this we are strongly disposed to consider as belonging to the same form, on account of the complete harmony in the degree of development of the platform and muscular scars. Our belief that these represent the same species is further confirmed by specimens before us of a distinct species of the genus, *R. Davidsoni*, sp. nov. (see Supplement), from the Niagara dolomites near Grafton, Wisconsin, in which are found the same imperfect development of the platforms, in association with a high cardinal area and erect beak. As already suggested, the pedicle-valve referred by WHITEAVES to *R. Galtensis*, resembles, as far as it is known, certain Monomerellas, and it will be important to look for interiors of this form which may lead to its correct allocation. Meanwhile *Rhinobolus Galtensis*, Billings, may tentatively be regarded as the type-species of the genus.

In regard to the generic characters of this species, the opinion held by DAVIDSON and KING, that they represent an extreme aberrant variation of

TRIMERELLA, linked to typical specimens of the genus by species like *T. Billingsi*, Dall, in which the platform-vaults are quite short, does not seem in accord with the persistent abbreviation of the platform and the entire absence of platform-vaults and umbonal cavities. We can, indeed, find an analogy to TRIMERELLA solely in the development of the deltidium of the pedicle-valve, while the similarity to DINOBOLUS in the structure of the platform is more apparent, though still remote. In the features of the brachial valve, however, the agreement with MONOMERELLA is by no means remote, as is seen in the marked difference of the central and lateral scars. Mr. DAVIDSON afterward abandoned his view expressed above, in regard to the relations of these forms, as we learn by an extract from a letter to Mr. WHITEAVES, quoted by the latter at page 8 of the Palæozoic Fossils, vol. iii, pt. 1:

"Although with much uncertainty this shell was placed, by Professor King and myself, in the genus TRIMERELLA, it is not a true TRIMERELLA, and should be removed from that genus. It is more closely allied to MONOMERELLA, and perhaps it would be better to retain Professor Hall's generic name of RHYNOBOLUS for its reception."

In addition to the features already mentioned, the species of RHINOBOLUS show, on both brachial and pedicle-valves, the broad terminal scars at the extremity of the sharply developed crescent, and, in the pedicle-valves, the umbo-lateral scars; the great trunks of the pallial sinuses are faint, though discernible.

OBSERVATIONS ON THE DEVELOPMENT AND FUNCTION OF THE PLATFORM IN THE INARTICULATE BRACHIOPODA.

THE specialized post-median testaceous deposit which has been termed the "platform" by Messrs. DAVIDSON and KING, occurs among brachiopoda only in the genera LAKHMINA, LINGULOPS, LINGULASMA, DINOBOLUS, TRIMERELLA, MONOMERELLA and RHINOBOLUS; it constitutes the principal diagnostic character of the *Family TRIMERELLIDÆ* of those authors, and in so far as any of these genera possesses this feature, so far, at least, is it a Trimerellid. In its chronogenesis it

is accompanied by certain peculiar phenomena. According to our present knowledge its first appearance is in the little LAKHMINA, from the primordial "Obolus-beds," in the Salt-Range of India, but in American faunas, where the development of the group is best exemplified, it is first met in DINOBOLUS (in external features the most oboloid form of the group), in the later faunas of the Lower Silurian; Black River, Trenton, Galena. Thereupon follow in the still later fauna of the Hudson group the more pronounced linguloid genera, LINGULOPS and LINGULASMA. Not, however, until the introduction of the Niagara or Wenlock fauna does the entire group, with the exclusion of the inceptive linguloid forms, reach its culmination in specific and individual development. The magnesian deposits constituting the Guelph and Galt limestones of the Province of Ontario, and the Niagara limestones of the interior of the United States, seem to have been accumulated under conditions favorable for the rapid increase of these animals, and yet, notwithstanding that in the limestones of the Niagara of New York, the Aymestry and Wenlock of England, and the Etage E–e_2 in Bohemia, these fossils have been found but sparingly, the equivalent faunas of the Island of Gotland, involved in essentially the same physical environment, produced certain of the genera in vast numbers. This was the period of the culmination of the Trimerellids, irrespective of their surroundings. With the disappearance of this fauna, the platform-bearing brachiopods virtually became extinct, and we have as yet no trace whatever of the occurrence of this peculiar feature at any later date, or in any other group of these animals.*

In the genus TRIMERELLA only, do we meet with a constant development of the platform in both valves, as a compound vaulted arch; in the other genera it is a solid plate, always showing a tendency to excavation on its more or less concave anterior walls, while DINOBOLUS furnishes frequent instances of this tendency being carried further toward the development attained in TRIMERELLA, though its vaults, when developed, are small, narrow and constricted, by no means bearing the same dimensional proportion to the platform as in the latter genus.

* In some genera of the articulate brachiopods the anterior and lateral edges of the muscular area is at times conspicuously elevated, for example, frequently in LEPTÆNA, STROPHOMENA, STROPHODONTA, and STREPTORHYNCHUS. To what extent this elevation is of the same nature and due to the same causes as the platforms of the Trimerellids, is yet to be determined.

Authors have suggested various functions for the chambers of the platform. LINDSTROM* regarded them as having been occupied by the adductor muscles; under this interpretation the arches would be conceived as the result of the progressive growth of the muscular fulcra or excessive shelly deposition about the base of the muscular bands. DAVIDSON and KING conceived them, "from their contiguity to the usual *locale* of the liver, to be the most likely receptacle for the divisions of this organ."† The same authors have also quoted‡ from a private letter of Mr. WHITFIELD, an opinion to the effect, that on account of the great size of the muscles required to work these ponderous shells, there would, of necessity, be a displacement of the essential organs, and that, under the force of this necessity, the platforms may have been developed to raise these large muscles from the center of the valve, and let the sexual organs pass beneath them. Such suggestions, however, can apply primarily, and in their entirety, only to TRIMERELLA, LAKHMINA, and such forms of DINOBOLUS in which the platforms are vaulted. These do not constitute the largest, or a fairly representative portion of the group, all the other genera, and DINOBOLUS usually, having the platform solid.

In order to apprehend more satisfactorily the functions of these specialized parts of the shell, we may turn our attention briefly to the relations of the platforms in the linguloid genera, LINGULOPS and LINGULASMA, to the muscular scars and fulcra in the true LINGULA.

While treating of the genus LINGULA, we have adverted to the fact, that the anterior and central muscular scars (*k*, *h*, of the pedicle-valve; *j*, *h*, of the brachial) may produce either distinctly localized impressions, indicating the space actually covered by the ends of the muscular bands at the time of the death of the animal, or may be much elongated, extending over nearly the entire visceral region, as seen in *L. Whitii*, *L. Elderi*, *L. punctata*, *L. lamellata*, and others (see Plates I and IV K); these large impressions indicating not correspondingly great muscles, but the advancing path of the respective bands as the shell has progressed in growth, only the anterior portion of the scar repre-

* Om Brachiopodenslagtet *Trimerella*.

† On the Trimerellidæ, p. 131.

‡ On the Trimerellidæ, p. 135.

senting the last place of attachment. In *L. anatina* these median scars are usually localized and excavated on the margin of the shelly thickening which covers the visceral area, and it appears that this thickening of the shell is largely due to the progressive deposition of testaceous matter about the insertion of the muscles; where the members of a muscular pair come into juxtaposition along the axis of the shell, the natural result of the union of these depositions is a median septum.*

Among the Lingulas which have passed under our observation, whether of fossil or recent species, it is seldom that any tendency is shown by these scars to become otherwise than thus terminal and excavated.

The first deviation in this respect toward the formation of a platform is found, without any known transitional forms, in LINGULOPS itself; not in the brachial valve, which actually possesses this organ in an incipient stage, but in the pedicle-valve as elsewhere described and illustrated. Here the muscular scars, which indicate large organs for such small shells, are concentrated well toward the middle of the valve, and their anterior edges are distinctly and abruptly elevated, placing the scars, by virtue of the stronger deposition of the shelly matter about the anterior edge of the area of insertion, upon, instead of beneath, the median thickening of the shell. How much of this change may be due to the increase in size and in the work required of the muscular apparatus does not appear in the minute and fragile shells constituting this genus, except that the impressions are large and all very sharply defined (a most striking feature in nearly all of the genera of platform-bearing shells is their great size and weight, necessitating powerful muscles to work them). In view of the close relations of the characters of this valve to those of LINGULA, we may venture to predict the discovery in the earlier palæozoic faunas, of some linguloid shell which will show in both valves just the stage of deviation from LINGULA toward TRIMERELLA that is indicated

* It is not the intention to give this suggestion so broad an application as to include all such septal phenomena in the brachiopods. It does apply to *Lingula anatina*, and to all Lingulas, as far as we are aware, whether the septa be axial or lateral: but it would be difficult to thus explain the origin of the great anterior extension of the septum into the brachiocœle, as seen in LINGULASMA, TRIMERELLA, etc. Such great vertical plates may, however, have had their source in septa of the character of those in LINGULA. Among the articulate brachiopods, the origin of median septa from similar causes is often apparent.

by the pedicle-valve of the earlier species of Lingulops (*L. Whitfieldi. L. Norwoodi*).

The brachial valve of this genus, with its little platform well defined, indicates a peculiar phase of accelerated development over its companion, and this same relation is manifested in *L. Granti*. which has the platforms developed in both valves, and also in Lingulasma, in both of which the brachial platform is the larger. The same feature occurs to some extent in the other genera.

It therefore appears probable that the inception of the platform is due to the slight variation indicated in the mode or rate of formation of the muscular fulcra in Lingula, and this may itself have been due, in part, to a simple increase in the size of the muscular bands.

In *Lingulops Whitfieldi*. the development of the platform of the brachial valve is not so far advanced as it appears in the other species of the genus: nevertheless, its surface is divided by a longitudinal depression, its anterior edge distinctly elevated, and its anterior wall slightly concave. In *L. Norwoodi* the brachial platform, in its relative proportions, is almost a miniature of that in Trimerella, being elongated, narrow, and divided for its entire length by a median depression, but not hollow, though with its anterior walls more concave or excavated than in its congener; and in *L. Granti*, of the Niagara fauna, essentially similar characters are manifested.

Another consideration concerning the origin of the platform is suggested by the chronological order of appearance of these fossils. The forms which have been just considered, and which indicate the line of derivation from Lingula to Trimerella (the latter genus being assumed to represent the climacteric development of the platform), are the predecessors of Trimerella, Monomerella and Rhinobolus: not remotely from a faunal standpoint, but actually, by a great lapse of time: the former are from the Hudson group, the latter from the Niagara faunas. Lingulops, strangely enough, has spanned this great interval, reappearing in the Niagara fauna with some important modifications, viz., the development of the muscular area of the pedicle-valve into a well-defined platform; possibly, also, the obliteration of the arched posterior scars. And Dinobolus, though attaining a culmination of development with its allies in the Niagara

fauna, dates as far back as the first introduction of the Trenton and Caradoc faunas in America, thus preceding in time the linguloid forms of our series. It therefore appears that this member of the group has received from some earlier, and probably different source, the characters which make it the nearest ally of TRIMERELLA. DINOBOLUS is the only member of this family with an oboloid form; its shells were much lighter, and may prove to have been less calcareous than in the rest of the group, not including LINGULOPS and LINGULASMA among the Trimerellidæ as constituted by DAVIDSON and KING.

The genus OBOLUS presents an interior so strikingly similar to that of DINOBOLUS, that the first known species of the latter genus, *D. Davidsoni*, was for many years referred to OBOLUS, by so acute an observer as Mr. DAVIDSON himself. The essential difference, however, between OBOLUS and DINOBOLUS is precisely that which we have just noticed between LINGULA and LINGULOPS, *i. e.*, the central "spectacle-scars" in OBOLUS are excavated and not elevated, lying, as in LINGULA, at the anterior margin of the thickened visceral area of the shell, while in DINOBOLUS they are elevated and upon the platform. The successive transition stages from the one form to the other are not so clearly demonstrated as in the line of descent from LINGULA. Attention, however, may be directed to the species described as *Obolella desiderata* by Mr. E. BILLINGS, the shell upon which Mr. S. W. FORD has established the genus ELKANIA. This is a species which attains about the size of *Obolus Apollinis*, Eichwald, and is larger than the Obolellas and Linnarssonias usually found in the associated faunas. In its brachial valve the central and lateral muscular scars are elongated, as usually in the Trimerellids, rather than localized as in OBOLUS, and are raised upon a well-defined platform, which is situated quite in the posterior or cardinal portion of the valve. The development of the platform in this valve is considerably in advance of the progress made in the opposite valve in the same direction, precisely as is the case in LINGULOPS. The pedicle-valve, however, shows that the corresponding muscular impressions are distinctly elevated, and, in front of the solid sub-triangular plate on which they rest, is a very deeply depressed area occupying the central portions of the valve and corresponding to the deep concavities having a similar position in all the Trimerellids. A very conspicuous feature of this

valve is the great post-median depression, which was considered by Mr. FORD as representing a pit for the reception of the pedicle, but the necessity for so large an organ in so small and light a shell, as this would imply, does not appear, and we have regarded it as the correlative of the central muscular scar in the opposite valve. From the anterior end of this scar are two narrow diverging furrows, the function of which is not understood, and the analogues of which have not been observed in any of the oboloid or indeed among the inarticulate brachiopods in general, save in the species *Monomerella Greenii*, where they attain the same relative development as in ELKANIA. It is possible that these furrows are specialized sinuses leading from the genitalia to the pallial vascular system, and performed the function of oviducts: their juxtaposition to the pallial trunks indicating some such office. Of still further importance in ELKANIA is the narrow furrow in each valve passing around the muscular area just within the cardinal margin, terminating laterally in a more or less well defined scar; in other words the first appearance, in the oboloid genera, of a distinctly developed crescent. As to their appearance in time, OBOLUS, ELKANIA and DINOBOLUS are successive.

If we have, thus, correctly suggested the source and development of the platform in the Trimerellids, we are confronted with the interesting phenomenon of a similar resultant attained along different lines of development. This may be expressed by the following diagram:

Obolella — Obolus — Elkania — Dinobolus

? (*Lakhmina*) - - - - - - - - - - - - - Trimerella.

Lingulella — Lingula — Lingulops — Lingulasma — Monomerella — Rhinobolus.

It is probable that the progenitor of OBOLUS will be found in OBOLELLA, or some of the closely allied genera, and our present knowledge of LINGULELLA is such that, as elsewhere observed, it must be placed in juxtaposition to OBOLELLA, while evincing a deviation toward LINGULA. The two are, in all probability, but a few removes from their common ancestor, which may be looked for in the earliest primordial faunas, unless its existence was limited to obliterated

faunas of still earlier date. RHINOBOLUS has the aspect of a degenerate Trimerellid, marked by the general obsolescence of the characteristic features of the group. In LAKHMINA, we have evidence that the platforms attained a considerable development before the introduction of Silurian faunas. Features, which in American faunas appear to have developed slowly, and whose different stages can be satisfactorily traced, seem to have been specialized with great rapidity in this obscure fossil. It is not necessary to assume that this fossil from a distant fauna, now regarded as of primordial age,* will materially modify the conclusions expressed in the foregoing diagram, derived from the study of American faunas.

Having indicated that the inception of the platform was probably due to augmented muscular energy and concomitant increased secretion of muscular fulcra, we may revert to the consideration of the function of this organ in its highest development, and to the inquiry, whether this attainment may have been acquired alone by the constant action of the forces named, or has been aided to this result by the accessory action of other organs.

Whether or not the platform be hollow as in TRIMERELLA and LAKHMINA, and sometimes in DINOBOLUS, or solid, as usually in DINOBOLUS, and always in the other genera, there is invariably a manifest tendency toward its excavation. The anterior walls are always concave; in MONOMERELLA the concavity of the plate is deep, the anterior moiety being turned with a steep slope toward the cavity of the shell; furthermore, the shell itself is much depressed beneath this projecting wall and on either side of the anterior median septum into which the platform is continued. The same features are seen in the brachial valve throughout these genera.† Even in RHINOBOLUS, all that is left of the platform is turned upward and inward at this sharp angle. In the pedicle-valve, however, this inclination of the platform, the excavation of its anterior walls and

* See page 29.

† Mr. ULRICH describes a peculiar structure in the platform of LAKHMINA. He says: "The cast of the interior which furnished the gutta-percha squeezes represented by figs. 5 and 5a" (see Pl. II, fig. 19), "originally preserved much of the shell and all of that pertaining to the platform. This was carefully removed, and during the process it was noticed that the platform consisted of numerous cup-shaped laminæ placed within one another, and so that an open space was left between each and the preceding and succeeding ones" (American Geologist, vol. iii, No. 6, p. 386. 1889).

depression of the surrounding surface of the shell is never so marked; the platform itself is of less size throughout, and we have noticed that in the course of its development it does not make its appearance so early as in the brachial valve. The lead held by the brachial valve in this respect, as shown in LINGULOPS and ELKANIA, is maintained throughout the entire history of the organ. The cause of this is not far to seek. In LINGULA, the anterior portion of the visceral region lying directly in front of, and behind the insertion of the anterior muscular bands, is occupied by the liver. In *L. anatina*, rather the greater portion of this body lies behind these muscular scars, but in LINGULOPS there is a general posterior concentration of all these muscular bands. In such a case the retrogression of the muscles could not force the liver into a more contracted space or otherwise displace it than to change its relative position and leave the large muscular bands behind it. This organ (the liver) is large, and lies mostly on the dorsal aspect of the animal, the surface there covered by it, in *L. anatina*, being considerably more extensive than on the opposite side. It is also distinctly bilobed by the longitudinal septum on the brachial valve. The pressure of this organ against the anterior edges of the area of muscular implantation must have been of significance in inducing the formation of the anterior elevated margins of the muscular scars, and in this pressure, continued as a constant force in both valves, though less intensely in one than in the other, may, perhaps, be found an efficient cause for the abrupt termination of the muscular area, its elevation, its concave anterior walls, and, eventually, its complete excavation, as well as the depression of the adjoining surfaces of the shell.

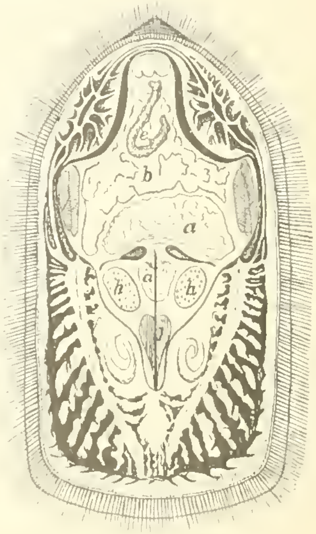


FIG. 17. *Lingula anatina.*

Ab oral aspect, showing the arrangement of the viscera on the inner surface of the brachial valve (after KING).

h, central scars. *a*, liver.
j, anterior lateral scars. *b*, genitalia.
c, alimentary canal.

In discussing the genus DINOBOLUS, attention has been directed to the tendency

occasionally manifested in both valves of the species to form two or three vaults on either side of the platform. In animals of the size indicated by these shells the lobation of the liver may have been so strongly developed as to produce this peculiar effect in the excavation of these cavities. Admitting the sequestration of the liver in TRIMERELLA, a freer play would undoubtedly be left to the muscles and greater opportunities of development, and this fact will have had both a direct and inverse bearing on the size attained by both the platform and the shell itself.

In regard to the great umbonal chambers of the pedicle-valve in MONOMERELLA, and their lesser development in DINOBOLUS and TRIMERELLA, they have possibly served a similar function to the platform-vaults, by removing the delicate genital organs from dangers which might arise from the action of the muscles. In *Lingula anatina*, these organs lie normally in the median and posterior portion of the visceral region, pressing backward against the post-parietal wall, and are placed mostly on the ventral side of the body. In offering an interpretation of the arched posterior scar in LINGULOPS, DAVIDSON and KING suggested that the middle sinus of the arch might have been produced by the umbonal muscle pressing against the parietal wall, and the lateral sinuses have been due to the pressure of the ovarian lobes against this muscular wall. Were this the case in the genus where all these features are in an initial stage of development, it would readily be conceived how by this constant pressure the genital organs may have developed the umbonal cavities for their own protection.

GENUS LINGULELLA, SALTER. 1866.

PLATE II, FIGS. 1-13.

1852. *Lingula*, MCCOY. Annals and Magazine of Natural History, Second Series, vol. viii, p. 405.
1852. *Lingula*, MCCOY. British Palæozoic Fossils, p. 252, pl. 1 L.
1859. *Lingula*, SALTER In Murchison's Siluria, Fourth Edition, p. 1[illegible].
1866. *Lingulella*, SALTER. Mem. Geological Survey of Great Britain, vol. iii, p. 333.
1866. *Lingulella*, DAVIDSON. British Silurian Brachiopoda, p. 55.
1867. *Lingulella*, SALTER. Quarterly Journal Geological Society, p. 340.
1868. *Lingulella*, DAVIDSON. Geological Magazine, p. 303.
1871. *Lingulella*, DAVIDSON. British Silurian Brachiopeda, p. 336.

(?) 1842. *Lingula*, EMMONS. Geology N. Y.; Rept. Second District, p. 267 (not fig. 68).
(?) 1847. *Lingula*, (CONRAD) HALL. Palæontology N. Y., vol. i, p. 3, pl. i, fig. 2.
1847. *Orbicula*, HALL. Palæontology N. Y., vol. i, p. 290, pl. lxxix, figs. 9*a*, *b*, *c*.
(?) 1860. *Lingula*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 76, fig. 1.
1861. *Lingula*, HALL. Annual Report Geological Survey of Wisconsin, p. 24.
1862. *Lingula*, BILLINGS. Palæozoic Fossils, vol. i, p. 71, fig. 64.
1863. *Lingula*, HALL. Sixteenth Rept. N. Y. State Cab. Nat. Hist., pp. 126, 127, pl. vi, figs. 4-8.
1867. *Lingula*, HALL. Transactions Albany Institute, vol. v, p. 103.
1871. *Obolella*, BILLINGS. Canadian Naturalist and Geologist, vol. vi, p. 218.
1871. *Obolella*, FORD. American Journal of Science, vol. ii, p. 33.
1871. *Lingulella*, MEEK. Proceedings Academy of Natural Sciences, Phila., vol. xxiii, p. 185.
1873. *Lingulella*, HALL. Twenty-third Rept. N. Y. State Cab. Nat. Hist., p. 245, pl. xiii, fig. 5.
1874. *Lingulella?*, BILLINGS. Palæozoic Fossils, vol. ii, p. 57, fig. 36.
(?) 1875. *Lingulella* (*Dignomia?*), HALL and WHITFIELD. King's Report U. S. Expl. Fortieth Parallel, p. 206, pl. i, figs. 3, 4.
1875. *Lingulepis*, HALL and WHITFIELD. King's Rept. U. S. Expl. Fortieth Parallel, p. 232, pl. i, fig. 8.
1878. *Lingulella*, FORD. American Journal of Science, vol. xv, p. 127.
(?) 1878. *Lingula*, WHITEAVES. American Journal of Science, vol. xvi, p. 226.
1882. *Lingulella*, WHITFIELD. Geological Survey of Wisconsin, vol. iv, p. 334, pl. xxvii, figs. 6, 7.
1884. *Lingula?*, (MATTHEW) WALCOTT. Bulletin No. 10, U. S. Geological Survey, p. 15, pl. v, fig. 8.
1885. *Lingulella*, MATTHEW. Illustr. Fauna St. John Group, No. 3, pp. 33, 34, pl. v, figs. 7, 8.
1886. *Lingulella*, WALCOTT. Bull. No. 30, U. S. Geol. Surv., pp. 95, 97, pl vii, figs. 1, 2; pl. viii, fig. 4.
1887. *Lingulella*, WALCOTT. American Journal of Science, vol. xxxiv, p. 188, pl. i, fig. 15.
1889. *Lingulella*, WALCOTT. Proceedings United States National Museum, 1888, p. 441.

DIAGNOSIS. "Shell nearly equivalve, broad-oblong, the ventral valve pointed, with a distinct pedicle-groove. Muscular scars strong, nearly as in OBOLUS, but the pair of anterior retractors are more linear and the sliding muscles small, and not quite external as in OBOLUS" (SALTER. Memoirs Geological Survey of Great Britain, vol. iii, p. 333. 1866).

Type, *Lingulella Davisi*, McCoy.

"The name LINGULELLA was first introduced about 1861, with the late Dr. S. P. WOODWARD'S full consent; and the name appears at p. 9 of Sir RODERICK MURCHISON'S Address to the Geological Section of the British Association, Manchester, 1861; but it is only in Mr. SALTER'S Appendix to the 'Memoir on the Geology of North Wales,' that the genus is for the first time described" (DAVIDSON, British Silurian Brachiopoda, p, 55. 1866).

OBSERVATIONS. Under the discussion of the genus LINGULA, attention has been directed to the peculiarities of the cardinal area in the type-species, *L. anatina*, and its close similarity with that of *Lingulella Davisi*. The necessity of great caution in assigning generic character from these features alone has also been expressed. In LINGULA the deltidium bears a broad pedicle-groove,

while in LINGULELLA the opening for the passage of the pedicle is a sharply defined slit, not merely making a depression upon the surface of the cardinal area, but apparently penetrating it from apex to cardinal line. Varying conditions of preservation will often make the determination of this feature difficult; but, aside from the character of the cardinal area, there is little known of the type-species of LINGULELLA which can be satisfactorily regarded as of generic value.* Mr. SALTER suggested a similarity in the muscular scars of *L. Davisi*, and those of OBOLUS and OBOLELLA: DAVIDSON, however, was unable to find examples of the species showing these impressions satisfactorily,† but called attention to the coarse punctæ over the visceral surface of one individual.

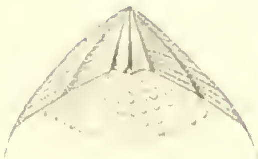


FIG. 18. Cardinal area of *Lingulella Davisi*, after DAVIDSON.

The generic term LINGULELLA has been used with considerable freedom by both American and English writers, but while there must remain a degree of uncertainty in regard to the correct generic character of many species now included under this name, there are a few primordial forms which are pretty well understood, both externally and internally; but whatever conclusions in regard to the generic features of LINGULELLA are derived from the study of these, must be dependent upon the results of future investigations upon the type-species, *L. Davisi*.

Mr. C. D. WALCOTT has given‡ figures of *Lingulella Ella*, Hall and Whitfield, which show not only the characteristic cardinal area and pedicle-slit, but give very distinctly the character of the muscular impressions on both valves. There will also be found on Plate I, figs. 1–4, of this volume, illustrations of the interior of both valves of *Lingulella cœlata*, Hall (ORBICULA, Hall, 1847,

* Dr. KING was strongly disinclined to admit the term LINGULELLA. In his work upon the "Characters of *Lingula anatina*," he says: "The deltidium is a variable structure in Palliobranchs generally; and its modifications are far from being understood. As regards the deltidium in the genus under consideration [LINGULA], one circumstance is remarkable: it has been in a great measure overlooked; at least I can find little, or rather no notice of it in the writings of previous observers. It is this oversight which led the late J. W. SALTER to institute his genus LINGULELLA, which he typified with the Cambrian *Lingula Davisi*, under the belief that its 'pedicle-groove' and 'hinge-area' do not characterize any species of the old Bruguièrian genus" (Ann. and Mag. Nat. Hist., Fourth Ser., vol. xii, p. 14. 1873).

† Silurian Brach., p. 55.

‡ United States Geological Survey, Bull. 30, pl. vii, fig. 2; and pl. viii, figs. 4 *a, b, c*. 1886.

OBOLELLA and LINGULELLA, Ford), which show a close agreement in the internal characters of these species.

In the pedicle-valve the lateral scars make the long sweeping curves so characteristic of OBOLELLA, while the centrals, more or less coalesced, produce a broad, somewhat tripartite scar. In the brachial valve of *L. Ella*, appear to be two diverging lateral scars, extending about one-half the length of the shell, and incurving at their anterior ends toward the more conspicuous and apparently compound central scar. Essentially the same characters are seen in the brachial valve of *L. cælata*, accompanied by posterior lateral scars, which occupy a position homologous with the terminal scars in the Trimerellids. An additional character is given to the muscular scars of the brachial valve in Mr. WALCOTT'S figures of his species, *Lingulella Granvillensis*,* in which there appears, near the center of the shell, a faintly defined, bilobed scar, continued anteriorly into an oval impression. These represent the "anterior adductor muscular scars, and also what may have been the adjustor muscular scars"† or the anterior laterals and the centrals of LINGULA. This feature constitutes a conspicuous difference from the obolelloid character of these impressions in the brachial valves of the other species cited, and it will be important to verify the character. The pedicle-valve of this species shows the straight (?) diverging ridges similar to those in *L. Dawsoni*.‡

Lingulella Ella, Hall and Whitfield.
After WALCOTT.

FIG. 19. Dorsal aspect, showing pedicle-area. FIG. 20. Internal cast of pedicle valve. FIG. 21. Internal cast of brachial valve.

Figures have been given by Mr. DAVIDSON, showing the muscular scars in the species *L. ferruginea*, Salter,§ and *L. lepis*, Salter.‖ In both these species the elongate, more or less curved laterals are apparent, enclosing a compound central scar not essentially differing from that in *L. Ella*, though more sharply outlined.

* American Journal of Science, vol. xxxiv, p. 188, pl. i, fig. 15 *a*. 1887.

† WALCOTT, *loc. cit.*

‡ By the favor of Mr. G. F. MATTHEW we are enabled to give an original figure of the interior of this species taken from the specimen represented in his "Illustrations of the Fauna of the Saint John Group," No. 3, pl. v, fig. 9 *d* (Trans. Roy. Soc. Canada, Sec. iv. 1885). We have not observed the sharply defined muscular impressions represented by Mr. MATTHEW.

§ Mon. Brit. Sil. Brach., pl. xlix, figs. 33*a*, 35*a*. 1871; and Geol. Mag., vol. v, No. 7, pl. xv, fig. 3*a*. 1868.

‖ Mon. Brit. Sil. Brach., pl. xlix, fig. 31*a*. 1871; and Geol. Mag., vol. v, No. 7, pl. xv, figs. 11 and 11*a*. 1868.

As long as our knowledge of the interior characters of LINGULELLA is limited to the few species cited, the genus may tentatively include such forms as have shown the high cardinal area and the distinct pedicle-slit. It is, however, in a broad sense, characteristic of the first or primordial faunas, and it has not been satisfactorily demonstrated that any species outside these faunas can be safely referred to the genus. *Lingulella Iowensis*, (Owen) Whitfield, is a proper LINGULA; *Lingulella Cincinnatiensis*, Hall and Whitfield, probably belongs to the same genus. The *Lingula paliformis*, Hall, of the Hamilton shales, has a distinct cardinal area, an apparently sharply defined pedicle-slit, with faint linear muscular or septal scars. It does not appear to be a true LINGULA, and, with our present knowledge, it is impossible to discover wherein it differs from LINGULELLA.

This genus has proved much more abundant in American than in European faunas, but of the twenty-five or more species which have appeared in American literature under this generic designation, fully two-fifths should be eliminated: while, on the other hand, some species passing current under the genus LINGULA may eventually prove to be LINGULELLA.

GENUS LINGULEPIS, HALL. 1863.

PLATE I, FIGS. 35, 36.

1847. *Lingula*, (CONRAD) HALL. Palæontology N. Y., vol. i, p. 3, pl. i, fig. 3.
1851. *Lingula*, HALL. Foster and Whitney's Rept. Geol. Lake Superior, p. 204, pl. xxiii, fig. 2.
1852. *Lingula*, OWEN. Rept. Geol. Surv. Wisconsin, Iowa and Minnesota, p. 583, pl. i *b*, figs. 4, 6, 8.
1863. *Lingulepis*, HALL. Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 129, pl. vi, figs. 12–16.
1875. *Lingulepis*, WHITFIELD. Ludlow's Rept. Reconnais. Black Hills, p. 103.
(?) 1876. *Lingulepis*. N. H. WINCHELL. Fourth Ann. Rept. Geological Survey of Minnesota, p. 11, fig. 6.]
1877. *Lingulepis*, HALL and WHITFIELD. King's Rept. U. S. Expl. Fortieth Parallel, pp. 206, 207, 232.
1877. *Lingulepis*, WHITFIELD. Prelim. Rept. Palæontology Black Hills, pp. 8, 9, pl. ii, figs. 5–9.
1882. *Lingulepis*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 169, pl. i, figs. 1, 2.
1884. *Lingulepis*, WHITFIELD. Bull. American Museum of Natural History, vol. i, No. 5, p. 141.

"SHELLS linguloid, inequivalve, equilateral, oval-ovate or spatulate; muscular impression in one valve, flabelliform: in the other, tripartite, the lateral divisions larger. Shell corneous, phosphatic."*

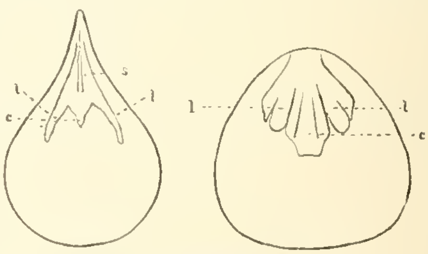
Type, *Lingula pinniformis*, Owen.

Since the original description of this genus, little has been added to our knowledge of its characters. The number of species that can be assigned to

* HALL. Sixteenth Report New York State Cabinet of Natural History, p. 126. 1863.

the group without hesitation is quite small, and if the generic features of the type-species *L. pinniformis*, are strictly adhered to, it may be necessary to restrict the specific representation to very narrow limits. The original species is the most thoroughly understood in both exterior and interior details. The external character of the shell itself, when both valves are present, allows of a ready distinction from all known forms of the genus LINGULA. The pedicle-valve bears a long, attenuate rostrum, which extends far beyond the apex of the opposite valve. This appears to have been open on the lower side for its entire length, for the passage of the pedicle, though we have no conclusive evidence that it may not have been partially covered by a thin deltidium of similar character to that in *Lingula anatina*. The brachial or dorsal valve is broadly ovate in outline, having an obscure beak and a general form which would be in precise agreement with that of the opposite valve, were the rostrum of the latter truncated at its base. The separated valves of *L. pinniformis* occur in great quantities in the Potsdam sandstone at the Falls of St. Croix, Minnesota and Wisconsin, crowded together to the exclusion of any other fossil, and there can be no doubt that the valves described in the Sixteenth Report of the State Cabinet of Natural History, as dorsal and ventral, are such, although no specimen has been seen in which the valves are in their natural juxtaposition.

The muscular impressions of the pedicle-valve may be determined with tolerable accuracy. A single large scar, occupying the entire umbonal region, is produced anteriorly into two narrow lateral branches, extending for about one-half the length of the shell. Between them and continuous with their posterior portion, lies a central scar, not extending so far forward, but together with the lateral branches giving the entire muscular impression a strongly tripartite character. The homology of these scars with those of LINGULA is not readily apparent, although there is a degree of similarity which is quite strongly shown in the outline of the central scars. Probably the entire muscular impression would, under perfect preservation, be resolvable into more detailed scars, but



FIGS. 22, 23. *Lingulepis pinniformis.*
l, lateral scars. *c*, central. *s*, septum.

there is no doubt that the conspicuous laterals correspond more or less exactly with the *laterals*, and the central scar with the *centrals* in LINGULA. LINGULEPIS also bears a broad and low median ridge, elevated along its margins and depressed in the middle, similar to, but fainter than that in *L. anatina*. Although the similarity to LINGULA in these respects is evident, a much closer homology is found in the muscular scars of this valve of LINGULEPIS and that of LINGULELLA. This is seen in the crescentic laterals and the prominent central in LINGULELLA. In OBOLELLA, the posterior coalescence of these scars is even more prominently developed than in LINGULELLA.

In the muscular scars of the brachial valve, the divergence from LINGULA is still more marked. These impressions make a conspicuous flabelliform scar, extending medially about one-half the length of the shell. The central portion of this scar is accompanied on either side by broader, partially resolvable lateral scars, all the subdivisions of the impression coalescing in the umbonal region. Here the crescentic laterals of LINGULELLA and OBOLELLA are quite absent, but the posterior coalescence of all the scars into one broad and ill defined impression, is a feature noticeable in all of these genera. Thus the genus LINGULEPIS affords an important connecting link between LINGULA and LINGULELLA in the direct line of relationship to OBOLELLA and its allied genera.

The shell-structure of LINGULEPIS is, presumably, closely similar to that of LINGULA, and, as usually in that genus, its surface-ornamentation is uniformly of concentric lines. *L. pinniformis* also shows a few faint radiating lines, which are more strongly developed on the internal surface over the anterior portion and on the interstitial lamellæ of the shell.

The genus, as far as known, is represented only in American primordial faunas; *L. pinniformis*, of the Potsdam sandstone of Minnesota and Wisconsin, finds a closely allied species in *L. antiqua*, Hall, of the same formation in New York. Two species, *L. cuneolus* and *L. perattenuata*, have been described from the Black Hills, by R. P. WHITFIELD,* and in the same year HALL and WHITFIELD† referred three species to this genus, *L. Ella*, *L. Mæra* and *L.? minuta*. The first of these has since proved a LINGULELLA, and it is probable that the

* Preliminary Rept. Geology of the Black Hills. 1877.

† KING's Report United States Geological Exploration Fortieth Parallel.

other two are to be referred to the same genus. Mr. WHITFIELD[*] has also described a species, *L. minima*, from the Potsdam sandstone of New York. Adding to these the *L. Morsensis* (*Morsii*) of N. H. WINCHELL,[†] we find that the genus is thus far represented by six species, but of all these the interior characters of the typical species only are satisfactorily known.

GENUS BARROISELLA, GEN. NOV.

PLATE II, FIGS. 11-16.

1868. *Lingula*, MEEK and WORTHEN. Geological Survey of Illinois, vol. iii, p. 437, pl. xiii, fig. 1.
cf. 1866. *Lingula*, DAVIDSON. British Silurian Brachiopoda, p. 42.
cf. 1870. *Lingula*, WINCHELL. Proceedings American Philosophical Society, vol. xiii, p. 248.
cnf. 1873. Genus?, KING. Annals and Magazine Natural History, Fourth Series, vol. xii, p. 13.
cnf. 1881. *Lingula?*, DAVIDSON. Brachiopoda Budleigh-Salterton Pebble-bed, p. 361.
cnf. 1887. *Lingula* (*Glottidia*), FRECH. Zeitschr. der deutsch geolog. Gesellsch., vol. xxxix, p. 392.

DIAGNOSIS. Shell externally as in LINGULA.

The pedicle-valve bears a high cardinal area, which does not appear to be a shelf, as in LINGULA and LINGULELLA, but a thickened triangular plate, which is divided by a broad pedicle-groove. On the basal margin of the cardinal area, at the angles made by the lateral margins of the pedicle-groove, is a pair of bosses or condyles, which have undoubtedly served either as muscular fulcra, or, to some extent, as points of articulation with the opposite valve. The interior of the pedicle-valve shows a subquadrate depressed area lying directly beneath and almost in continuation of the pedicle-groove; this may represent the umbonal muscular scar. From its ante-lateral angles diverge two sharply defined, linear depressions, which extend about one-fourth the length of the shell and end abruptly. From outside and behind the extremities of these depressions, begins a pair of long, curved furrows, which are composed of two shorter curves, the posterior rounding over the extremities of the linear depressions referred to above, the anterior and longer curves gradually approximating and nearly meeting at a point about one-third the shell's length from the anterior margin. These furrows are accompanied by low ridges along their inner margin. A low median ridge, with elevated edges, begins at the posterior umbonal impression, and continues to the center of the valve, widening near

* Bulletin American Museum of Natural History, vol. i, No. 5, p. 141, pl. xiv, figs. 1, 2. 1884.
† Geology of Fillmore County, Minnesota. 1876.

its anterior extremity. Just behind its termination is a pair of small, usually indistinct muscular impressions, probably the scars of the central muscles.

In the brachial valve the beak is scarcely prominent, and the muscular markings are essentially as in the opposite valve, but more sharply developed. Beneath the beak is a faint umbonal scar, the diverging lines from which are discernible. The long, compound lateral curves have a considerably greater degree of curvature than in the pedicle-valve, their posterior portion enclosing a thickened area, which is continued into a peculiar low and thickened median septum, bifurcating in the middle of the valve, the angle being occupied by an intercalated ridge, which extends for twice the length of the branches of the septum. This peculiar bifurcation may be due to the impression of the anterior muscular scars at this point. The central scars are situated further backward at the junction of the median septum with the posterior thickened area.

Type, *Lingula subspatulata*, Meek and Worthen.

OBSERVATIONS. There can be no sufficient reason to doubt the generic difference of shells possessing the above characters from described linguloids. The condyles on the cardinal margin are themselves a distinctive feature. We have already directed attention to Dr. KING's observations upon this peculiarity in *Lingula? Lesueuri*, Rouault,* a species which shows evidences upon the cast, of two deep pits close to the beak. In his opinion this character alone is sufficient to exclude the species from the genus LINGULA. Mr. DAVIDSON subsequently compared† this species (*L. Lesueuri*) with the recent *Glottidia Palmeri*, Dall, finding in both the development of a median septum in the pedicle-valve and two lateral septa in the brachial valve. Just such septal features are found in the pedicle-valve of *B. subspatulata* if we choose to consider the diverging umbonal furrows as homologous with the lateral septa in GLOTTIDIA; but they are not found in the brachial valve. The other internal markings of this species are widely different from those of LINGULA. The central muscular scars are

FIG. 21. *Lingula? Lesueuri*, Rouault
Internal cast of pedicle-valve.
After DAVIDSON.

* *Vide supra*. Annals and Magazine Natural History, July, 1873, p. 13.

† Brachiopoda Budleigh-Salterton Pebble-bed, p. 362.

placed very far back, especially in the brachial valve, where the thickened area against which they abut, and the semicircular lateral impressions bounding the area, suggest the compound central muscular thickening and the curved lateral scars seen in some species of OBOLELLA. The long curved anterior furrows in both valves at once suggest homology with the vascular trunks or pallial sinuses in LINGULA. No specimens of these shells, however distinctly the interior markings may have been preserved, give any indication of branches from either side of these furrows, and it may be well to bear in mind in determining the relations of the genus, their similarity to the long laterals in OBOLELLA.

On the basis of interior characters, *Lingula subspatulata* is the only species known that can be safely referred to this genus. This form was described by MEEK and WORTHEN in 1868,* from the black shales (Genesee horizon) underlying the Goniatite limestone (Kinderhook) near Rockford, Indiana, and Union county, Illinois. Professor A. WINCHELL† has suggested the specific identity of a form found in the black shales at Vanceburg, Kentucky, and elsewhere on both sides of the Ohio river, included within the Waverly series, but this is evidently a higher horizon than the Indiana and Illinois occurrence, and we surmise that the Waverly form mentioned by Professor WINCHELL will prove to be the *L. Melie*, Hall. The same author also suggests the identity of *L. subspatulata*, Meek and Worthen, with his *L. membranacea*, from the Burlington sandstones. The only figure we have of this latter form is one given by MEEK‡ in 1875, in which there are indications of the high cardinal area and apophyses in the former species, though the quadrate outline of *L. membranacea* gives it a specific impression distinct from that of *L. subspatulata*. The *Lingula paliformis*, Hall, of the Hamilton shales of New York, may also prove to belong to BARROISELLA, though the character of the cardinal area and the internal markings as far as now known, do not serve to distinguish it from LINGULELLA. With BARROISELLA may be compared the Bohemian species *Lingula Davidsoni*, Barrande,§ and *L. insons*, Barrande,‖ from the Etage D.

* Geological Survey of Illinois, vol. iii, p. 437, pl. xiii, fig. 1.

† Proceedings American Philosophical Society, vol. xii, p. 248.

‡ Palæontology Ohio, vol. ii, pl. xiv, fig. 4.

§ Système Silurien, vol. v, pl. 104, fig. viii.

‖ Système Silurien, vol. v, pl. 105, fig. x.

Genus TOMASINA,* gen. nov.

Under the name, *Lingula Criei*, Mr. Davidson described, in 1881,† a linguloid fossil from the Armorican grit of the Département de la Sarthe, having a cardinal area of such peculiar structure as to render its separation from the genus Lingula necessary.

Lingula Criei. After Davidson

Figs. 25, 26 Internal cast and interior of posterior portion of pedicle-valve.

Fig. 27. Internal cast of pedicle-valve. Natural size

"The pedicle-valve is very slightly convex, its posterior margin being notched. This notch is divided into two parts by a small triangular elevation, leaving on each side a well defined depression or little cavity. Aside from this slight elevation, the valve presents a gentle longitudinal convexity, which extends a little in front of the center of the valve, the lateral portions of the shell remaining almost flat. The opposite valve appears to have been somewhat more convex than that we have described.

"This notch in the area for the passage of the pedicle is very remarkable, and I have never before observed it in any of the numerous species of the genus which I have studied. In the interior of this same valve, beneath the pedicle-aperture, there are two small processes with a depression between them, and the central muscular impressions are well defined, but I have been unable to find any other impressions upon the internal casts which M. Guillier has sent me."

The internal processes upon the cardinal margin are so large that they may have served purposes of articulation to some extent. In this respect the fossil shows structure similar to that seen in its associate in the same fauna, *Lingula? Lesueuri*, Rouault.

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* Out of regard for the memory of Mr. Davidson, to whom we are indebted for our knowledge of this fossil, the above name is proposed.

† Bulletin de la Société Géologique de France, p. 372. 1881: Note sur les Lingules du grès armoricain de la Sarthe, par M. A. Guillier, avec descriptions et figures des espèces, par M. Th. Davidson, pl. vii.

Genus OBOLELLA, Billings. 1861.

PLATE II, FIGS. 31-44.

1847. *Orbicula?*, Hall. Palæontology N. Y., vol. i, p. 290, pl. lxxix, figs. 8 a, b.
1847. *Avicula?*, Hall. Palæontology N. Y., vol. i, p. 292, pl. lxxx, figs. 3 a, b.
1852. *Obolus*, Owen. Geological Survey of Wisconsin, Iowa and Minnesota, pp. 501, 631, pl. 1 b.
1860. *Lingula?*, Hall. Annual Report Geological Survey of Wisconsin.
1861. *Obolella*, Billings. Geology of Vermont, vol. ii, p. 946.
1862. *Obolella*, Billings. Geology of Canada; Palæozoic Fossils, vol. i, p. 7.
1862. *Obolella*, Meek and Hayden. Proceedings Acad. Nat. Sci. Phila., vol. xiii, p. 435.
1863. *Obolella?*, Hall. Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 133, pl. vi, figs. 17-21.
1865. *Obolella*, Meek and Hayden. Palæontology Upper Missouri, pp. 3, 4.
1866. *Obolella*, Davidson. British Silurian Brachiopoda, p. 60.
1871. *Dicellomus*, Hall. Advance sheets Twenty-third Rept. N. Y. State Cab. Nat. Hist.
1871. *Obolella*, Billings. Canadian Naturalist and Geologist.
1872. *Obolella*, Billings. American Journal of Science, vol. iii, p. 355.
1873. *Obolella*, Ford. American Journal of Science, vol. v, p. 213.
1876. *Obolella*, Billings. American Journal of Science, vol. xi, p. 176.
1877. *Obolella?*, Hall and Whitfield. King's Rept. Exploration Fortieth Parallel, p. 205.
1880. *Obolella*, Whitfield. Palæontology of the Black Hills, pp. 339-341.
1881. *Obolella*, Ford. American Journal of Science, vol. xxi, p. 131.
1884. *Obolella?*, Walcott. Palæontology Eureka District, p. 67.
1886. *Obolella*, Walcott. Bulletin No. 30, U. S. Geological Survey, pp. 109-119.
1889. *Obolella*, Walcott. Proc. U. S. National Museum, vol. xii, p. 36.

Diagnosis.* Shell inarticulated, ovate or suborbicular, lenticular, smooth, concentrically or radiately striated, sometimes reticulated by both radiate and concentric striæ. Ventral valve with solid beak and a small, more or less distinctly grooved area. In the interior of the ventral valve there are two elongated, sublinear or petaloid muscular impressions, which extend forward from near the cardinal scars, sometimes to points in front of the mid-length of the shell. These are either straight or curved, parallel with each other or diverging toward the front. Between these, at about the middle of the shell, is a pair of small impressions, and close to the hinge-line a third pair, likewise small, and often indistinct. There is also, at least in some species, a small pit near the hinge-line, in which the groove of the area seems to terminate.

The dorsal valve has a small, nearly flat hinge-facet; the minute beak is slightly incurved over the edge of the area. Beneath the beak there is a small subangular ridge, on each side of which there is a cardinal (?) scar. The elon-

* Derived from Mr. E. Billings' diagnosis in 1872 (*loc. cit.*) and the emended description of the type-species, *O. chromatica*, by the same author in 1876 (*loc. cit.*).

gate scars, which seem to correspond to the laterals of the ventral valve, are here altogether in the upper half of the shell, diverging widely in their extension forward, and are generally very slightly impressed. In the cavity of the valve there is a low, rounded median ridge, which extends from a point near the hinge-line forward to a little below the mid-length of the valve. About the middle of the shell there are two small scars. These are usually striated longitudinally, the median ridge passing between them. The area is coarsely striated.

Type, *Obolella chromatica*, Billings.

OBSERVATIONS. Since the date of Mr. BILLINGS' studies of OBOLELLA,* much valuable information in regard to the character of the interiors of these shells, especially of the brachial valve, has been contributed by Mr. S. W. FORD, in various papers in the American Journal of Science, and by Mr. C. D. WALCOTT, in Bulletin No. 30 of the United States Geological Survey. Mr. BILLINGS assumed three species as types of his genus: (1) *O. chromatica*; (2) the *Avicula? desquamata*, Hall (= *O. crassa*, Hall) from the limestones near Troy, N. Y.; (3) "A small species from the Potsdam sandstone of the St. Croix River," which had been described by Professor HALL as *Lingula? polita*,† and was subsequently‡ referred with some degree of doubt to the genus OBOLELLA.

Obolella chromatica.
After BILLINGS.
FIG. 28. Interior of pedicle-valve.
FIG. 29. Interior of brachial valve.

The original figures of *O. chromatica*, the first-mentioned type-species, gave but a very imperfect representation of the character of the interior of the pedicle-valve, and showed only the two elongate lateral muscular scars.§ Subsequently the figures here copied, were published by Mr. BILLINGS in the American Journal of Science,‖ giving the interiors of both valves, as far as then known to him; previously, however, in the same journal,¶ he

* Palæozoic Fossils, vol. i, 1861; Canadian Naturalist, 1872; Amer. Jour. Science, 1872; *Idem*, 1876, etc.

† 1860. Report Geological Survey Wisconsin.

‡ 1863. Sixteenth Report N. Y. State Cab. Nat. Hist.

§ Palæozoic Fossils, vol. i, p. 7.

‖ Vol. xi, 1876, p. 176.

¶ Vol. iii, 1872.

had given excellent figures, showing very completely the characters of the pedicle-valves of *O. desquamata* (= *O. crassa*, Hall), and *O. gemma*, Billings. But in 1863,* the interiors of both valves of *Obolella? polita*, Hall, had been illustrated, and the figure given of the pedicle-valve (there termed "dorsal?") represents the impressions almost precisely as we now know them to be in the corresponding valve of *O. chromatica*, *O. crassa*, and others; while those of the opposite valve, usually less distinctly retained than in the pedicle-valve, show the long, curved laterals and the central scar. (See further under discussion of DICELLOMUS.) In 1881, Mr. FORD† demonstrated the interior characters of the brachial valve of *O. crassa*, subsequently amplifying his observations somewhat in a figure published by Mr. WALCOTT in Bulletin No. 30, 1886. In this work, Mr. WALCOTT also gives a figure of the interior of the same valve of *O. chromatica*, demonstrating the complete harmony of its scars, both in arrangement and development, with those of *O. crassa*. The same author gives, in addition, illustrations of the interiors of *O. gemma*, and *O. Circe*, Billings.

The genus OBOLELLA possesses, as far as known, a larger specific representation than any other group of primordial brachiopods, but all species that have been referred to the group are not congeneric. The true OBOLELLA, as far as it is accurately known, is not only confined to primordial faunas, but is believed to be largely American in its representation. The forms referred by English writers to the genus fail to show the characteristic generic features. Some of them have already been assigned to other genera, *e. g.*, *O. sagittalis*, Salter, to LINNARSSONIA, Walcott, to which genus probably belong *O. Belti*, Davidson, and *O. maculata*, Hicks; *O. Sabrinæ*, Callaway, will undoubtedly prove a representative of a distinct genus, its relations to ACROTRETA having been pointed out by Mr. WALCOTT.

Certain of M. BARRANDE's species show internal features indicating their close alliance to OBOLELLA, *e. g.*, *Lingula Feistmanteli*,‡ *Obolus? complexus*,§ *Obolus*

* HALL. Sixteenth Rept. N. Y. State Cab. Nat. Hist. (*loc. cit.*).

† American Journal of Science, vol. xxi, p. 131.

‡ Syst. Sil. Bohême, vol. v, pl. 106, fig. iv.

§ Syst. Sil. Bohême, pl. 95, fig. iii; pl. 111, fig. vi; pl. 152, fig. ii. 4.

*advena.** These are all from the Etage D, and should they prove referable to Obolella, will constitute the latest recorded appearance of the genus.

The American species which can safely be classed as Obolella are the following: *O. chromatica*, Billings, *O. crassa*, Hall, *O. Circe* Billings, *O. gemma*, Billings, and probably *O. polita*,† Hall.‡ Of other species referred to the genus by American writers, it may be remarked:

O.? ambigua, Walcott,§ will probably prove referable to the genus Elkania, as suggested by the author of the genus, Mr. Ford.‖

O. cœlata, Hall, = *Lingulella cœlata* (*Orbicula cœlata*, Hall¶).

O. cingulata, Billings. = *Kutorgina cingulata*.

O. desiderata, Billings,** is the type-species of Elkania.

O.? discoidea, Hall and Whitfield:†† generic character in doubt, as the interiors are not known.

O.? Ida, Billings,‡‡ is imperfectly known.

O.? misera, Billings,§§ is referred to the genus Linnarssonia, by G. F. Matthew.‖‖

O. nana, Meek and Hayden.¶¶ Mr. Walcott is disposed to consider this

* Syst. Sil. Bohême, pl. 95, fig. iv.

† The *Lingula prima* (Conrad's MS. description, first published by Hall, Pal. N. Y., vol. i, p. 3. 1847), from the Potsdam quartzite at Ausable Chasm, N. Y., has been referred by Mr. Whitfield (Bull. American Museum Nat. Hist., vol. i, No. 5, p. 142. 1884) to the genus Obolella, and is also identified by him with the species *O.? polita*, Hall, from the yellow pulverulent sandstones at Trempeleau, Wisconsin, so that, should this identification hold good, the latter name will become a synonym of the former. The identification is, however, made solely on the basis of external similarities, and must be regarded as subject to such modifications as the interior charactèrs, when known, may require. These have not been satisfactorily demonstrated in the New York species, but there are specimens before us which indicate that its muscular impressions are more nearly those of Lingulella than of Obolella. The *Obolella nitida* of Mr S. W. Ford, also considered by Mr. Whitfield a synonym of the same species (*op. cit.*), appears, from an examination of the type-specimens, to be a totally distinct fossil.

‡ Under the name *Obolella Atlantica*, Mr. Walcott has mentioned, without giving a detailed description, an additional species from the Olenellus zone, Conception Bay, Newfoundland (Proceedings U. S. National Mus., vol. xii, p. 36. 1889).

§ Palæontology Eureka District, p. 67, pl. i, figs. 2 a–c. 1884.

‖ American Journal, vol. xxxi, p. 467. 1886.

¶ Palæontology N. Y., vol. i, p. 290, pl. lxxix, fig. 9.

** Palæozoic Fossils, vol. i, p. 69. 1862.

†† Geographical and Geological Exploration Fortieth Parallel, p. 205, pl. , figs. 1, 2. 1877.

‡‡ Palæozoic Fossils, vol. i, p. 71, figs. 63 a, b. 1862.

§§ Palæozoic Fossils, vol. ii, p. 69. 1874.

‖‖ Illustrations Fauna St. John Group, No. iii, p. 35. 1885.

¶¶ Palæontology Upper Missouri, p. 4, pl. i, figs. 3 *a–d*.

species as identical with *O. polita*, Hall,* but specimens of both species, from the original localities of each, show differences in the much less convexity of *O. nana*, its more triangular outline, and its usually smaller size. Should these differences prove constant, the species may be regarded as well defined.

O. nitida, Ford.† Mr. FORD's specimens show a very tenuous phosphatic shell which has not retained any trace of the internal characters.

O. pretiosa, Billings.‡ Interiors of the type unknown. Mr. WALCOTT suggests their relationship to ACROTHELE;§ but specimens which have been placed in our hands by Sir WILLIAM DAWSON, from the Quebec group at Little Metis, and which show no external differences from *O. pretiosa* as described by BILLINGS, have all the internal characters of the genus LINNARSSONIA.

O. transversa, Hartt, = LINNARSSONIA, Walcott.

Our discussion of the generic characters of OBOLELLA must, therefore, be limited to observations made upon the authentic species cited.

Primarily, a distinct cardinal area is developed in each valve. On the pedicle-valve this feature is much the more conspicuous, and is crossed by a pedicle-groove, which is not a slit cut through the area, but only a depression on its surface. The brachial valve on the other hand shows only a broad sinuate depression as seen in the figure of *O. gemma* given on Plate II (fig. 43 [34 in error]); in *O. crassa* this valve has a somewhat triangular area with a very slight ridge occupying a position correlative to the pedicle-groove of the other valve. Mr. FORD's figure, given in Bulletin No. 30, United States Geological Survey,|| makes this feature much stronger than it actually appears in the specimen from which the drawing was made. Though the same feature is shown in Mr. WALCOTT's figure of the brachial valve of *O. chromatica*,¶ it remains to be determined whether or not it is a constant character in these species.

* Bulletin No. 30, U. S. Geological Survey, p. 111.
† American Journal of Science, 1873, vol. v, p. 213.
‡ Palæozoic Fossils, vol. i, p. 68. 1862.
§ Bulletin No. 30, U. S. Geological Survey, p. 111.
|| Pl. x, fig. 1 *a*.
¶ Bulletin No. 30, U. S. Geological Survey, pl. xi, fig. 1 *b*.

The latter author also describes and figures* a brachial valve of *O. gemma* from Bic Harbor, below Quebec, in which the cardinal area is quite narrow and bears a deep pedicle-groove. It is possible that this feature may be subject to so great variation within the limits of the same species as indicated by Mr. WALCOTT's figure and our own; but this point requires verification.

FIG. 30. Brachial valve of *O. gemma*. After WALCOTT.

In the pedicle-valve the groove on the area is followed by a deep pedicle muscular impression, which is flanked on either side by narrow, elongate cardinals. The lateral scars begin near the pedicle-pit or scar and curve gently outward, and again inward near their distal extremities, extending two-thirds, sometimes three-fourths the length of the shell. They are not always a simple groove, but in *O. crassa* each margin of the impression is more deeply sunken than the rest, thus leaving a low ridge between them. In the post-median region, the central scars are usually ill-defined but evidently compound, and in *O. crassa* are seen to consist of three subcircular scars, two outer and one inner; these are bordered on the anterior side by a series of thread-like ridges and furrows. In *O. gemma* the entire central scar is more deeply impressed, and partakes of the tripartite character, the median portion being the most prominently developed.

In the brachial valve, the laterals take their origin in the median region of the shell, adjacent to, or in the central impressions, and curve outward. An excellently preserved interior of this valve of *O. crassa* shows a subrhomboidal central scar with straight sides and with the apex pointed posteriorly; the margins are more depressed than the center, but the impression is not divided by a ridge into two scars, as represented in Mr. FORD's figure.† The laterals branching from this scar are very broad and slightly curved. In other species the central impression is usually indefinite in its details, as in the pedicle-valve, but shows a subdivision into outside and median scars

The cardinals in *O. crassa* are well defined and, at their anterior extremities,

* Bulletin No. 30, U. S. Geological Survey, p. 117, pl. x, fig. 2 *d*.

† Bulletin No. 30, U. S. Geological Survey, pl. x, fig. 1 *d*.

merge into a pair of elongate submarginal scars, which may be termed the *externals*. They appear to represent the terminal crescent scars in the Trimerelloids, but cannot, with propriety, be regarded as correlates of the great laterals of the opposite valve (see FORD, WALCOTT, *op. cit.*).

The term DICELLOMUS was proposed in March, 1871, in a paper published in advance of the Twenty-third Annual Report on the Condition of the State Cabinet of Natural History, for the species which had been previously described as *Obolella? polita*,* the *Lingula? polita*, Hall, 1860,† and the *Obolus Apollinus*, Owen, 1852.‡ This species was also the third type under BILLINGS' diagnosis of OBOLELLA. DICELLOMUS was also made to include, as a second type, the *Orbicula? crassa*, Hall, 1847, but this latter species proves to be congeneric with *Obolella chromatica*. The interior characters of the former species are still somewhat imperfectly known, the original illustrations of them which are reproduced upon Plate II (figs. 40, 41), being somewhat constructive, but the pedicle-valve, while showing an unusually strong cardinal area, has the pedicle-groove, the cardinal, lateral and central muscular scars, quite as in typical Obolellas; in the brachial valve the apparent correspondence of the scars with those of *Obolella chromatica* and *O. crassa* is less marked. Upon this plate are given additional figures of the interior of this species, the pedicle-valve (fig. 38) showing two very strong centrals, bounded, on the posterior margin, by a thickened, triangular area, extensions from which pass between and around the outer sides of the scars. The outer posterior margins of this area bear the impressions of the cardinal or external muscles, while below the position of the pedicle-groove (the cardinal area is not retained on this specimen) lies a pedicle-scar. The whole appearance of this interior is strongly suggestive of that in OBOLUS, but may not prove inconsistent with the character of OBOLELLA. In the brachial valve, the impressions are more distinctly obolelloid, the long, curved laterals taking their origin at the compound central scar. The development of the interior details of the shells of this species is a matter of much difficulty, as the

* Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 133. 1863

† Annual Report Geological Survey Wisconsin, p. 24.

‡ Report Geological Survey Wisconsin, Iowa and Minnesota.

substance of the shell is friable and chalky, and the sandstone so loose-grained that internal impressions are not distinctly retained. Should future study of the species prove it generically distinct from *O. chromatica*, it will be necessary to accord recognition to the term DICELLOMUS, which, however, may be held in abeyance until that time. There is a noticeable similarity in the interior of the pedicle-valve of *O. polita* as shown in fig. 38, to the illustration given by VOLBORTH of the interior of the corresponding valve in the species *Schmidtia celata*,* in which all the details represented are the two strong central scars abutting against a thickened posterior area. The correspondence in internal markings does not appear to extend to the brachial valves. (See discussion of the genus SCHMIDTIA.) Attention may also be directed to the *Obolus ? complexus* of BARRANDE,† from the Etage D, apparently a genuine OBOLELLA, in a later fauna than has been elsewhere observed.

FIG. 31. *Obolus ? complexus* After BARRANDE.

GENUS LEPTOBOLUS, HALL. 1871.

PLATE III, FIGS. 1-10.

1871. *Leptobolus*, HALL. Descriptions New Species Fossils, p. 3; Advance sheets Twenty-fourth Rept. N. Y. State Mus. Nat. Hist.

1872. *Leptobolus*, HALL. Twenty-fourth Rept. N. Y. State Mus. Nat. Hist., p. 226, pl. vii, figs. 17-20.

1875. *Leptobolus*, HALL and WHITFIELD. Palæontology of Ohio, vol. ii, p. 69, pl. i, figs. 10, 11.

DIAGNOSIS "Shell semiphosphatic, fragile, minute, more or less elliptical, ovate or subcircular, with moderately (or sometimes more extremely) convex valves, which are concentrically marked on the exterior surface. Ventral valve with a distinct pedicle-groove; interior with an elevated subquadrate muscular area. Dorsal valve a little thickened on the cardinal margin, with slightly elevated, trifid muscular impressions," HALL (*loc. cit.*).

Type, *Leptobolus lepis*, Hall, Hudson group, *loc. cit.*, p. 226, pl. vii, figs. 19, 20.

L. occidens, Hall, Hudson group, *loc. cit.*, p. 227, pl. vii, fig. 18.

L. insignis, Hall, Utica slate, *loc. cit.*, p. 227, pl. vii, fig. 17.

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* Verhandl. der russ.-kais. Mineral. Gesellsch. zu St. Petersb., 2te Ser., Bd. iv, taf. xvii, fig. 1. 1868.

† Système Silurien Bohême, vol. v, pl. 152, fig. ii, 4; also, pl. 95, fig. iii; pl. 111, fig. vi; pl. 113, fig. v.

Observations. There is a noticeable variation in the internal characters of the species referred to this genus, but it does not appear to be of an essential nature, or of a greater degree than might be expected in different species; indeed this variation is strikingly apparent in different individuals of the same species.

Of the interiors of the three known species of Leptobolus, that of *L. occidens* is not yet satisfactorily known, but those of both the other species are of not uncommon occurrence. *L. lepis* is found in the Utica slate of New York, at Holland Patent, and elsewhere, having been washed by thousands into the rill-marks or depressions in the sediment, but upon cleaving the rock the shells are exposed with their interiors usually attached to the matrix, making it necessary to remove the scale-like shell in order to ascertain the internal characters. In the gray, muddy shale of the lower part of the Hudson group of Ohio (Utica horizon), the same species has accumulated in great numbers, and by breaking the rock the interiors are usually exposed; the specimens are, therefore, in a much more favorable condition for study. *Leptobolus insignis*, readily distinguished from *L. lepis* by the radiating striæ on its internal surface, is found in much the same condition of preservation, but in the more compact layers of the Cincinnati or Hudson group. It will be understood that shells washed about as these have been, may often have lost the clear definition of their delicate interior impressions, but examples are not infrequent which retain with great sharpness all the internal details.

The interior of the pedicle-valve shows a notably large cardinal area, which is sharply grooved. Beneath this area, in the bottom of the valve, is a broad depression extending nearly across the shell, and divided by a low median ridge, which bifurcates at its extremity, leaving between its branches a small central muscular impression. This latter feature is more clearly developed in *L. lepis* than in *L. insignis*, but in the latter species the entire depression is much more clearly defined, its ante-lateral margins being produced slightly forward. This impression is bounded on its sides by a crescentic muscular fulcrum, which extends, parallel with the margins, to the anterior portion of the shell. At a point back of their centers, each gives out a transverse branch extending in-

ward and backward. These callosities are strongly suggestive of the appearance produced by the combined lateral and central scars in *Obolella chromatica* and *O. crassa*, and it is probable that they represent the same features, in which case the posterior depressed area is to be regarded as the progressive track of the centrals, its anterior margin advancing with age.

The position of the valve lying between the anterior horns of the lateral semilunes is also deeply depressed, but its surface shows no markings. The specimens of *L. lepis* from the Cincinnati rocks appear not to have retained these lateral callosities, but they are faintly developed in the New York examples of the same species.

In the brachial valve, the cardinal area has about the same degree of development as in OBOLELLA, and is also distinctly grooved. The muscular scars in this valve are poorly defined, but their limits are probably indicated in part by the septa, which in *L. lepis* are three in number; one in the axial line larger than the rest, and one on either side. All these ridges appear to be bifurcated at their anterior extremities, in the axial ridge the faint duplication beginning at about the center. In the Utica slate specimens of *L. lepis* the lateral ridges, in the only satisfactory example observed, appear to be curved inward toward their extremities, as they also are in *L. insignis* where they attain a very conspicuous development, uniting with each other in front and being separated from the margin of the shell only by a low furrow. These ridges may be regarded as the curved fulcra of the lateral muscles.

The features seen in LEPTOBOLUS indicate its close alliance to OBOLELLA, but are at the same time so diverse from those of *Obolella chromatica* that the forms can not be regarded as congeneric.

GENUS ELKANIA, FORD. 1886.

PLATE III, FIGS. 15-19.

1862 *Obolella*, BILLINGS. Palæozoic Fossils, vol. i, p. 69, fig. 62 a, b.
1884. *Obolella?*, WALCOTT. Palæontology Eureka District, p. 67, pl. i, fig. 2.
1886. *Billingsia*, FORD. American Journal of Science, vol. xxxi, p. 466.
1886. *Elkania*, FORD. American Journal of Science, vol. xxxii, p. 325.

This genus has been established by Mr. S. W. FORD upon the late Mr. BILLINGS' species, *Obolella desiderata*, from the Graptolite shales at Pointe Lévis. We have

had before us for the study of this form, Mr. BILLINGS' original specimens, which give very clearly the interior characters of both valves. These were lucidly described by the author, although he was not disposed to regard them as generically distinct from *Obolella chromatica.* This description, given upon page 70 of the work cited, is in the following terms:

"From some nearly perfect casts of the interior, the following characters can be made out. In one of the valves (supposed to be the ventral) a strong rounded groove commences just beneath the beak, and runs along the median line to about the center of the shell. On each side of the principal groove is a large ovate muscular impression, extending from near the mid-length of the shell a little more than half-way to the beak. These impressions are bounded and distinctly defined at their lower extremities by the two small, diverging grooves above mentioned. Their outer and upper margins are distinctly defined. In the rostral part of the shell there are two small grooves which take their origin close to the beak, one on each side, and run toward the front, diverging to the outside of the upper part of the two large muscular impressions. The characters of the interior of the dorsal valve are somewhat similar to those of the ventral valve, but the median groove is shorter, and there is a thickening of the shell just below the beak, which presents the appearance of a false area inside the cavity of the umbo. It is probable that the two small grooves above mentioned are connected with the small muscular impressions, which, in *O. chromatica*, are distinctly seen outside of the two larger. The condition of our specimens, however, is such that this point must remain open for further investigation."

In subsequently proposing to designate this shell by the term BILLINGSIA (a name afterwards changed to ELKANIA as the former proved to have been already in use), Mr. FORD gave a much enlarged and somewhat schematic figure of the pedicle-valve (which we are disposed to believe emphasizes rather too strongly the internal characters), and accompanies it with the following diagnosis of the generic characters (*loc. cit.*, page 467):

"Shell thin, calcareous, inarticulate, longitudinally ovate or subcircular, convex. Ventral valve with a solid beak and a minute area, which, in the typical species, is grooved for the passage of the pedicle as in OBOLELLA. Muscular impressions in the ventral valve, six; one pair situated close to the cardinal

edge, one on either side of the median line; a second, smaller pair, placed directly below the former: and outside of the latter a third pair of large elongate or subreniform impressions, converging forward. Beneath the rostrum there is a prominent spoon-shaped pit or chamber separating the above mentioned impressions, with which the groove of the area is confluent. In the dorsal valve there are also three pairs of impressions disposed in nearly the same manner with those of the ventral valve. The dorsal valve is not known to possess an area. The surface is concentrically striated."

From the specimens before us, the shell-substance of *Elkania desiderata* appears to be largely corneous and distinctly laminated. Several examples in which the external layer of the shell has been exfoliated are covered with conspicuous papillæ which may indicate a punctate structure in the inner layers, a feature not hitherto noticed in Obolella or its immediate allies. We have not been able to discover the minute cardinal area mentioned by Ford, although this feature should have been retained on the specimens examined, if it was distinctly developed. On the contrary, there appears to be, just within the marginal apex of what is above considered as the ventral valve, a broad, subtriangular depression, into which the central "spoon-shaped" cavity merges. This central cavity, in five examples of the interior of this valve, has a more or less distinct development, its definition being sometimes obscured by the flattening of the shell. When best preserved, it shows two narrow furrows diverging from its anterior extremity, which continue a short distance and become abruptly extinct. These two furrows separate the anterior extremities of the broad lateral muscular scars, which are quite indistinctly limited, while the smaller impressions, termed by Ford the "centrals", are faint, but distinctly seen in favorable light. The two small grooves in the rostral portion of the shell, diverging from the beak, were regarded by Ford as constituting the "cardinal" scars. These are, however, very elongate, and pass from near the pedicle-groove outward, skirting the posterior portion of the lateral impressions, and appear to terminate in distinct, subcircular scars situated between the laterals and the lateral margins of the valve. Should this character prove of permanent value, it will be of significance as affording an analogy between Elkania, Obolus and the Trimerellids.

The opposite valve shows the very peculiar feature mentioned by Mr. Billings, a thickened area in the umbonal region presenting the appearance of a false cardinal area inside the cavity of the umbo, a character which is suggestive of that in Lingulasma, but evidently of different function. This area is tripartite, bearing a deep, narrow central and two broader lateral grooves; about its anterior margin lie two broad scars of the same character as the laterals of the other valve. There are also seen the diverging furrows, which, starting at the marginal apex, pass over the edge of the thickened area, and are most deeply impressed at their anterior extremities.

To homologize the muscular features seen in Elkania with those of Obolella or any allied genus, is a difficult matter. Mr. Ford was disposed to regard the central depression of the pedicle-valve as an extravagant development of the pedicle-pit seen in *O. crassa* and *O. chromatica*. This appears very plausible, but complicates the correspondence of the other scars; and, moreover, as the internal scars of the opposite valves do not essentially differ in their number and arrangement, it would compel the assumption of a pedicle-pit in the brachial valve. Mr. Ford has suggested that Walcott's species, *Obolella ? ambigua*,* from the "Pogonip group" of Nevada, is congeneric with *E. desiderata*. Mr. Walcott's figures, 2a, 2e, of the interior of the pedicle-valve, indicate the unquestionable correctness of this reference.

Genus PATERULA, Barrande. 1879.

PLATE IV K, FIG. 1.

1879. *Paterula*, Barrande. Système Silurien du Centre de la Bohême, vol. v, p. 110, pl. 95, figs. i, 1–3; pl. 152, figs. i, 1–9.

1884. *Paterula*, Davidson. General Summary to British Fossil Brachiopoda, p. 391.

Diagnosis. "Les deux valves, circulaires ou faiblement ovalaires, ne présentent qu'un bombement très peu prononcé vers l'extérieur. L'espace interne devait donc être très exigu.

"Ces deux valves se rencontrent habituellement isolées. Cependant, nous figurons Pl. 152, deux spécimens de valves juxtaposées, qui paraissent avoir appartenu à un même individu. Nous pouvons ainsi constater, qu'il n'existe

* Palæontology Eureka District, p. 67, pl. i, fig. 2.

aucune fissure, sur la surface ni de l'une, ni de l'autre valve. Ce fossile n'est donc pas une *Discina.* Mais nous observons, au contraire, la trace d'une perforation sur le bord. Elle est indiquée par une petite cylindre de la roche, qui la injectée et qui fait saillie sur le contour." BARRANDE, *loc. cit.*

Type, *Paterula Bohemica*, Barrande. Etage D.

The position of this genus, as far as it rests upon the character of the pedicle-aperture, appears to be near that of SCHIZOBOLUS, while the narrow internal septa diverging from the beak suggest relationship to LEPTOBOLUS. The nature of the shells is not well understood, but it is evident, from the description and figures given by the author, that it is allied to those forms in which the pedicle-passage is in the first stages of its transition from the intermarginal obolelloid condition, to the supramarginal phase developed in SIPHONOTRETA, etc.

FIG. 32. *Paterula Bohemica.* After BARRANDE.

In the "General Summary the British Fossil Brachiopoda" (p. 391), Mr. DAVIDSON has referred to this genus his species *Discina? Balcletchensis*, a form occurring in great numbers in the Llandeilo and Upper Caradoc, and though like the Bohemian species in the character of its broad marginal rim, no evidence is afforded of the pedicle or internal characters. We have received from Mr. H. M. AMI the only American specimens which we should feel disposed to refer to this genus. An enlarged figure of a gutta-percha impression taken from the best of these, is given on Plate IV K, fig. 1, and shows the conspicuous rim, the pedicle-notch, and the radiating muscular impressions taking their origin about an intramarginal callosity. This shell is from a black limestone in the city of Quebec, currently referred to the age of the Quebec group.

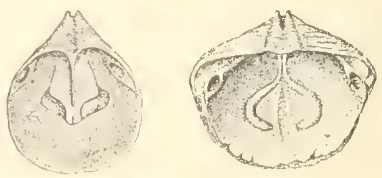
A NUMBER OF GENERA having more or less close relationship to OBOLELLA have been described by European writers, but are not at present known to have representatives in American faunas. Such are OBOLUS, MONOBOLINA, SPONDYLOBOLUS, ACRITIS, SCHMIDTIA, MICKWITZIA and NEOBOLUS. The original specimens of these genera are mainly from primordial faunas, but they are to a great degree imperfectly known, the figures and descriptions given by various authors not always serving the requirements of the present status in the investigation of these fossils. Much has yet to be learned in regard to the internal characters of most of them before their generic position can be established.

OBOLUS, EICHWALD. 1829.

1829. *Obolus*, EICHWALD. Zoologia specialis, vol. i, p. 271.
1830. *Ungula*, PANDER. Beitr. zur Geogn. des Russisch. Reiches., p. 55.
1840. *Orthis*, VON BUCH. Beitr. zur Bestimmung der Gebirgsform. Russlands.
1847. *Aulonotreta*, KUTORGA (*partim*). Ueber die Siphonotretææ, p. 278.
1848. *Ungulites*, BRONN. Index Palæontologicus, vol. iii, p. 1342.
1871. *Ungulites*, QUENSTEDT. Petrifactenk. Deutschl. Brachiopoden, p. 671.

Type, *Obolus Apollinis*, Eichwald. Unguliten-schichten.

This is the best known and most thoroughly studied of all the genera above named. Externally the shells are much like those of OBOLELLA, but are generally larger and somewhat flatter. The valves are unarticulated, both having broad, grooved cardinal areas, though the groove on the brachial valve is sometimes obsolescent. The interior of the pedicle-valve* shows a pair of well-defined cardinal or posterior adductor impressions, just behind the cardinal area and separated by a more or less developed median septum extending to about the center of the valve. The "laterals" are well developed and occupy a position not equivalent to the



Obolus Apollinis.
FIG. 33. Pedicle-valve. After DAVIDSON.
FIG. 34. Brachial valve. After KUTORGA.

* KUTORGA and DAVIDSON (Introd. Brit. Foss. Brach., pl. x, figs. 280–285) have not agreed in the determination of the valves of OBOLUS. Of KUTORGA's figures of *Aulonotreta polita* (= *Obolus Apollinis*), those lettered 10 *b*, *b'*, *c* and *d* (*op. cit.*, pl. vii), are considered by the author as interiors of the *dorsal* (brachial) valve, and figure *e*, that of the *ventral* (pedicle-) valve. DAVIDSON considered, and with excellent reason, figs. 10 *b* and *b'* as dorsal and *c*, *d* and *e* as ventral valves.

impressions in OBOLELLA which have been designated by this term, but more nearly to that of the terminal scars of the crescent in DINOBOLUS. The median area of the valve on each side of the septum is much thickened, and at its anterior edge lie the conspicuous central scars. In the brachial valve the cardinal and "lateral" (external or terminal) impressions are developed as in the opposite valve, and in the central region is a pair of curved impressions suggestive of, and probably corresponding to the elongate laterals in OBOLELLA. These enclose an indistinct central scar.

The affinities of OBOLUS with the linguloids are somewhat remote and general, but are seen in the character of the cardinal area and the disposition of the central muscular scars in the pedicle-valve. The strongly thickened median area of the same valve, which is given prominence by the excavated central scars, is suggestive of a rudimentary platform such as is found with greater development in LINGULOPS, LINGULASMA and the Trimerellids. This, however, may be an homology only, as the muscular scars in OBOLUS are not situated upon, but at the anterior margin of this area. The external muscular impressions with the ridge proceeding from them backward, toward the umbo, suggest the crescent in DINOBOLUS, and are the equivalents of the terminal crescent scars in that genus and the externals in OBOLELLA, while the curved laterals in the brachial valve show, as just noticed, the near relationship to the latter genus.

A species from the St. John group, at Caton's Island, King's county, New Brunswick, has been referred to this genus by Mr. G. F. MATTHEW,* but we have, as yet, no knowledge of its interior characters, and the reference requires verification. The exterior of both valves of this shell is ornamented in the umbonal regions by a reticulated punctation which is apparently superficial. This becomes obsolete with the later growth of the shell. (See Plate IV K, fig. 22.)

* *O. pulcher*, Matthew. Canadian Record of Science, January 1889, p. 306.

GENUS AULONOTRETA, KUTORGA. 1848.

1848. *Aulonotreta*, KUTORGA. Ueber die Siphonotretææ: Verhandl. der Russ.-kais. Mineral. Gesellsch. zu St. Petersb. Jahrg. 1847, p. 278, pl. vii, figs. 10, 11.
1869. *Acritis*, VOLBORTH. Ueber Schmidtia und Acritis, *idem.*, 2te Ser. Bd. iv, p. 217, pl. xvii, figs. 7–9.

The name AULONOTRETA was proposed by KUTORGA to take the place of OBOLUS, Eichwald, as he deemed the latter an inappropriate name. The first type-species under the description is *A. polita*, Kutorga, which "umfasst folgende, von Professor EICHWALD, aufgestellte Arten: *Obolus Apollinis*, *O. Siluricus* und *ingricus*, deren unterscheidende Merkmale weder mit Worten, noch mit Zeichnungen gegeben werden konnen."* As *O. Apollinis* is, however, generally recognized as a well-defined species, KUTORGA's first type and his genus, as far as it rests on this type, became synonyms for OBOLUS. The second type, *Aulonotreta sculpta*, Kutorga, is a synonym for the *Obolus antiquissimus*, Eichwald,† and this species was taken by VOLBORTH as the type of his genus ACRITIS.‡ The species is very imperfectly known. VOLBORTH's figures indicate a close agreement with OBOLUS in general form, and the characters of the cardinal area. The incomplete interiors figured show in the pedicle-valve, a broad, subquadrate median scar, crossed on its posterior portion by a transverse band connecting what appear to be cardinal scars. In the brachial valve are two subcircular scars in the median region just within the posterior margin. In the event of this form proving distinct from OBOLUS, the laws of priority require that it shall bear the name AULONOTRETA, for which ACRITIS will then be a synonym.

Acritis antiquissima.
After VOLBORTH.
FIG. 35. Interior of pedicle-valve.
FIG. 36. Interior of brachial valve.

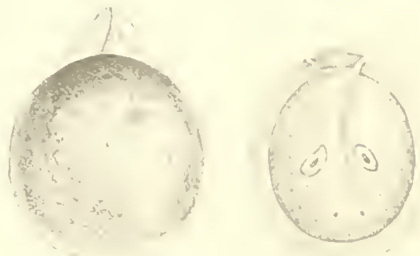
* Pp. 281, 282.
† Urwelt Russl., 1843, p. 142, pl. iv, fig. 1 *a, b, c.*
‡ *Loc. cit.*

GENUS SCHMIDTIA, VOLBORTH. 1869.

1869. *Schmidtia*, VOLBORTH. Ueber Schmidtia und Acrotreta: Verhandl. der Russ.-kais. Mineral. Gesellsch. zu St. Petersb. 2te Ser. Bd. iv, p. 213, pl. xvii, figs. 1–6.

Type, *S. celata*. Unguliten-schichten.

The shells of this genus have the form and external characters of LEPTOBOLUS, Hall. The pedicle-valve has a broad grooved area, and in the middle of the valve are two rather deep depressions separated by an elevated ridge, and having abrupt posterior margins, but with their anterior edges illy defined. These features may be compared with those seen on the interior of *Obolella polita*, Hall (see plate ii, fig. 38). In the opposite valve is a median ridge, with a rather more sharply defined pair of elliptical depressions. Mr. DALL observes* that the name SCHMIDTIA was preoccupied in 1863 for a genus of PORIFERA



Schmidtia celata
After VOLBORTH.
FIG. 37. Interior of pedicle-valve
FIG. 38. Interior of brachial valve.

GENUS MONOBOLINA, SALTER. 1865.

PLATE IV K, FIGS. 2, 3.

1865. *Monobolina*, SALTER. Mem. Geol. Survey Great Britain, vol. iii, p. 334, pl. xi b, figs. 10, 10 a.
1866. *Obolella?*, DAVIDSON. British Silurian Brachiopoda, p. 61, pl. iv, figs. 20–27.
1871. *Obolus?*, DAVIDSON. British Silurian Brachiopoda, Appendix, p. 341, pl. l, figs. 23, 24.
1884. *Obolus*, DAVIDSON. British Silurian Brachiopoda, General Summary, p. 291.

"Section MONOBOLINA, muscular scars united closely along the central line." SALTER (*loc. cit.*).

Type, *Lingula plumbea*, Salter. 1859. Lower Llandeilo.

The later figures given by Mr. DAVIDSON of the interior of the type-species show that the peculiar concentration of the muscular impressions as indicated by Mr. SALTER, is strikingly different from anything seen in OBOLUS, OBOLELLA,

* Bull. U. S. Nat. Mus., No. 8, p. 62.

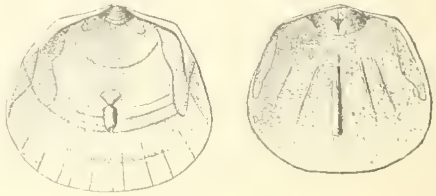
or the allied genera. Though Mr. DAVIDSON, in all his citations of the species, was in doubt as to its generic character, he did not manifest an inclination to adopt Mr. SALTER's name; but from our present knowledge it seems that the term MONOBOLINA must be accorded recognition. Externally the valves are covered with strong radiating striæ, as in the brachial valve of SCHIZOCRANIA.

GENUS NEOBOLUS, WAAGEN. 1885.

1885. *Neobolus*, WAAGEN. Memoirs Geol. Surv. India: Salt-Range Fossils, pt. i, vol. iv, fas. 5, p. 756.

Types, *Neobolus Warthi*, Waagen, *loc. cit.*, p. 758, pl. 84, figs. 3–8.
N. Wynnii, Waagen, *loc. cit.*, p. 759, pl. 85, figs. 1, 2.

This peculiar genus from the primordial beds* of the Salt Range of India, presents some important deviations from the oboloid type of structure.



Neobolus Warthi.
After WAAGEN.
FIG. 39. Interior of pedicle-valve.
FIG. 40. Interior of brachial valve.

In general form and outline the shell is oboloid with a somewhat transverse posterior margin, which is slightly thickened, and in the pedicle-valve is traversed by a broad, cross-striated pedicle-groove. The cardinal muscular scars lie close upon this groove; the central scars are faint, and in the figure indistinctly defined, but are seen to abut against "a short thickened ridge or knob" in the middle of the shell. Most striking are the broad marginal scars occurring on both valves, and which appear to represent the external scars in OBOLUS, and the crescent in DINOBOLUS and its allies. In the brachial valve a strong longitudinally grooved callosity lies just within the cardinal margin, and this is more or less distinctly continued into a median septum. The arrangement of the muscular scars other than those referred to, is not fully understood.

* See remarks on page 29.

Genus SPONDYLOBOLUS, McCoy. 1852.

1852. *Spondylobolus*, McCoy. Annals and Magazine Natural History, vol. viii, p. 407.
1853. *Spondylobolus*, Davidson. Introd. Brit. Foss. Brachiopoda, p. 125; pl. ix, figs. 211–213.
1855. *Spondylobolus*, McCoy. British Palæozoic Fossils, p. 255, pl. I H, figs. 4, 5.

Types, *Crania Sedgwicki*, Lewis, *C. craniolaris*, McCoy. Lower Llandeilo.

(The former species is not considered a Brachiopod by Mr. Davidson; *vide* Silurian Brachiopoda, p. 83, pl. viii, fig. 25.)

Very little is known of this genus except from the original description given by McCoy, and the figures subsequently produced in the "British Palæozoic Fossils, p. 255, pl. I H, figs. 4, 5. Mr. Davidson, from the first, expressed his doubt of its generic value, but he has reproduced the original figures in both the places cited. In the latter* he promises a further reference and explanation of the fossil. We have not, however, been able to find anything of later date, further than a casual mention of the name,† and even the species does not appear in any of his various lists and indexes.

McCoy's diagnosis of the genus is as follows:

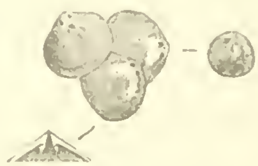


Fig. 11. *Spondylobolus craniolaris.* After McCoy.

"Subcircular, slightly narrowed towards the indistinct, short hinge-line, nearly equivalve, flattened. Small valve with a slightly excentric apex; beneath which, on the interior, the substance of the valve is thickened into a wide, undefined boss. Opposite valve slightly longer, from the apex being perfectly marginal and slightly produced, channeled by a narrow, triangular groove below, the anterior end of which is flanked by two very prominent thick, conical, shelly bosses, representing hinge-teeth; substance of the valve thick, testaceous, not glossy, minutely fibrous, but not distinctly punctated under a lens of moderate power, except by the ends of these fibres."

With our imperfect knowledge of this fossil, little can be said further than to suggest its general obolelloid appearance, and the possibility that its cardinal bosses may indicate a similar relation between it and Obolella as is found to exist between the species of the genus Barroisella and the true Lingulas.

* Expl. pl. viii, figs. 26, 27.

† General Summary, 1884, p. 352.

Genus MICKWITZIA, Schmidt. 1888.

1888. *Mickwitzia*, Schmidt. Ueber eine neuendeckte untercambrische Fauna in Estland; Mém. de l'acad. imp. des Sciences de St. Pétersbourg, vii Ser., tome xxxvi, No. 2, p. 24.

Diagnosis. Shells large, thick, unequivalve. Dorsal valve flat, circular; ventral valve oval, convex, produced into an acute apex, beneath which lies a triangular, more or less distinctly developed cardinal area. Valves not (?) articulated. Shell-substance composed of thin coarsely punctate layers alternating with prismatic laminæ which are traversed by scattered vertical canals. Surface covered with radiating striæ. Shell composed of calcic phosphate.

Mickwitzia monilifera.
After Schmidt.
Fig. 42. Pedicle-valve. Fig. 43. Interior of same valve.
Fig. 44. Exterior of brachial valve.

Type, *M. monilifera*, Linnarsson.

This name has been proposed by Dr. Schmidt for a shell which had been described by Linnarsson in 1869,* from the Eophyton sandstone, the oldest fossil-bearing formation of Sweden, and referred at that time to the genus Lingula (?), ; subsequently by the same author in 1871,† to Obolus (?). More abundant material found near Reval has shown various features which have led to its establishment as a separate genus. The shell has the general appearance of Obolus, and its relationship to this genus is shown in the external characters, and the grooved cardinal area. Unfortunately none of Dr. Schmidt's specimens give a satisfactory indication of the internal characters, so that the generic value of the species must still remain in great doubt. A remarkable feature is shown in a single figure of the interior of the smaller valve, viz, a single large tooth-like process, situated centrally behind the beak, and bent at a sharp angle backward into what would have been the umbonal region of the opposite valve.‡ Dr. Schmidt is not convinced that this is to be regarded as a

* Öfver. af K. Vetensk. Akad. Förhandl. p. 344, t. vii, figs. 1, 2.

† Kongl. Svenska Vetensk. Akad. handlingar, Bnd. 9, No. 7, p. 9, pl. i, figs. 2, 3.

‡ Schmidt, pl. ii, fig. 16.

permanent feature of the species and genus (p. 22), it having been observed in but a single instance; but should more complete material establish its persistence it would serve not only as a feature of generic distinction, but would remove this form far from the Oboloids (cf. *Crania? Sedgwicki*, Lewis: DAVIDSON, British Silurian Brachiopoda, p. 83, pl. viii, fig. 25, which is believed not to be a brachiopod).

SCHIZOBOLUS, ULRICH. 1886.

PLATE III, FIGS. 11-14.

1862. *Discina*, HALL. Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 28.
1867. *Discina*, HALL. Palæontology of N. Y., vol. iv, p. 23.
1873. *Trematis*, HALL. Twenty-third Rept. N. Y. State Mus. Nat Hist., pl. xiii, fig. 20.
1886. *Schizobolus*, ULRICH. Contributions to American Palæontology, vol. i, p. 25, pl. iii, figs. 3 a d.

DIAGNOSIS. "Shell oval, depressed-convex, slightly inequivalved; valves inarticulate; structure calcareo-corneous. Cardinal margin somewhat thickened.

"Ventral valve with the apex at the terminus of a rather deep notch in the posterior margin; interior of the valve with two pairs of adductors, separated by a faint median ridge or septum which traverses the valve from the posterior margin, where it is bifurcated, to a point about two-thirds the length of the valve from the anterior margin. The posterior adductors are very faint.

"Dorsal valve with the posterior margin straightened. the apex subterminal and but little elevated; interior of valve with a slender median septum which separates two pairs of faintly impressed muscular scars; the posterior pair large, oval and situated just in front of the cardinal margin, the anterior pair are less distinct, smaller, of triangular shape, narrowest in front, and situated near the anterior end of the mesial septum.

"Very faint impressions of lateral muscles were observed near the margin of both valves." (ULRICH, *loc. cit.*)

Type, *Discina truncata*, Hall.

The type-species of Mr. ULRICH's genus was described first in 1862, and subsequently, with illustration, in 1867 (*loc. cit.*), as *Discina truncata*, from the Genesee slate of Seneca county, New York. In both these places attention was called to the fact that the muscular impressions, as far as observable, differed from those of DISCINA. Subsequently the species was referred to the genus TREMATIS, Sharpe (1873, *ut. cit.*), on account of the sharply triangular

foramen on one of the valves. The New York specimens have, however, not proved so satisfactorily preserved as those of the same species from the Black shale of Kentucky, and from a study of the latter, Mr. ULRICH has determined the generic relations of this interesting fossil to be quite distinct from what had been previously assumed. By the favor of Mr. CHARLES SCHUCHERT we have had the opportunity of studying Mr. ULRICH's type-specimens, and, in addition to these, have had access to a considerable number of specimens from the Genesee slate of New York. Though compelled to differ in some respects from Mr. ULRICH's diagnosis of this fossil, our observations agree with his in most essential points. The muscular impressions and fulcra are so faintly defined, even on the best preserved specimens, that allowance may readily be made for personal differences of observation; for this reason, however, extreme care has been taken to ascertain the permanent, and eliminate the fugitive characters of this, the only species known to represent the genus.

In the pedicle-valve the groove or slit is very short, sometimes appearing as a mere notch in the posterior margin, but, when well retained, comes to an acute termination at a point about one-tenth the distance across the valve. When the valve is uncompressed, this slit lies wholly on the posterior subapical slope.

On the interior of this valve a faint ridge is continued forward from the proximal end of the slit, extending to a point about one-third the distance across the valve. This is flanked on each side by a low muscular callosity which narrows anteriorly and leaves the septum projecting on the median line. The margin of this callosity is grooved by distinct muscular impressions, and the groove extends about the anterior edge of the septum.

The scars abutting against this callosity may be termed the *centrals*, and they have essentially the same character as in the genus OBOLELLA. From the post-lateral margins of the callosity extend narrow curved lateral scars, reaching to, or beyond the center of the valve, and though not always discernible they appear with great distinctness on the best preserved specimens. At the position of the cardinal scars as seen in OBOLELLA, are sometimes depressions in the shell that may indicate the point of attachment of such muscles.

In the brachial valve, the posterior portion of the margin is considerably more flattened and that portion of the outline of the valve quite transverse. Directly within this margin, and parallel to it, is a narrow thickened band, which may be analogous to the callosity occupying a similar position in WAAGEN'S genus NEOBOLUS. There is also a muscular thickening or callosity of about the same size and character as that seen in the pedicle-valve, but somewhat more flabellate, less distinctly defined, and not satisfactorily resolvable into separate scars. A faint median septum begins near the posterior margin of this area and grows in size until the anterior end is reached, whence it rapidly disappears. No evidence has been found of curved laterals similar to those in the pedicle-valve Mr. ULRICH'S figures show in both valves peculiar circular scars situated near the lateral margins. These are mentioned in the diagnosis as being "very faint" and indeed are visible only on the best preserved specimens, and there only under the most favorable illumination. If it can be demonstrated that these markings actually represent muscular scars and are not the result of a slight exfoliation, they will prove a feature of much importance. None of the forms of OBOLELLA, or allied genera known in primordial or Silurian faunas, show a combination of the elongate curved lateral scars with such additional impressions, and we find an analogous occurrence only in the genus LAKHMINA, Œhlert, from the Salt Range of India,* a genus with a well-developed platform, remarkable not only as being the earliest representative of the Trimerellids, but also for its synthetic characters, for in association with the "laterals," or outside marginal scars, which undoubtedly represent the terminal impressions of the crescent, are the peculiar curved laterals of OBOLELLA. Better material must be examined in order to determine the existence or non-existence of these crescent scars in SCHIZOBOLUS. This genus, with our present knowledge, appears to be a very late representative of the true obolelloid type, as pointed out by Mr. ULRICH, varying therefrom more in the character of its pedicle-slit and cardinal area than in any other feature, but in its triangular pedicle-opening indicating a relationship to TREMATIS and SCHIZOCRANIA.

* See WAAGEN, Mem. Geol. Survey of India Salt Range Fossils, vol. i, pt. iv, fasc. 5, p. 764, pl. lxxxv, fig. 6, 1885; *Davidsonella linguloides*.

Externally the shell is characterized by its posterior apices, fine concentric striæ, and general similarity to "DISCINA." The shell-substance is tenuous and appears to be wholly corneous.

GENUS DISCINOLEPIS, WAAGEN. 1885.

1885. *Discinolepis*, WAAGEN. Mem. Geol. Survey of India, Palæontologia Indica: Ser. xiii, Salt-Range Fossils, I. Productus-limestone Fossils, iv (fas. 5), Brachiopoda, p. 749.

DIAGNOSIS. "The shell is of very small size with two unequal valves, which are very flat, leaving scarcely any room for the animal between them.

"The lower ventral valve is hardly at all vaulted in any direction, and appears flatly spread out like a small fish-scale, only the apex is a little elevated. It is removed from the margin towards the median part of the valve. The margin of the valve nearest the apex is broadly cut out by a deep incision reaching to the top of the apex.

Discinolepis granulata.
After WAAGEN.
FIG. 45 Pedicle-valve. FIG. 46. Brachial valve.

"The upper or dorsal valve is in shape similar to the other one, with a slightly elevated eccentric apex, but without an incision.

"The surface in both valves is either smooth or covered with a fine granulation." (WAAGEN, *loc. cit.*)

Type, *Discinolepis granulata*, Waagen. Pl. lxxxvi, figs. 5–7. "Obolus Beds," Salt Range = Primordial.

GENUS KUTORGINA, BILLINGS. 1861.

PLATE IV, FIGS. 10-20.

1861. *Obolus*, BILLINGS. Geology of Vermont, vol. ii, p. 946.
1861. *Kutorgina*, BILLINGS. Geology of Vermont, vol. ii, p. 948 (foot-note).
1863. *Obolus, Obolella*, BILLINGS Geological Survey of Canada, pp. 248, 284.
1864. *Obolella*, HOLL. Quarterly Journal Geological Society, vol. xxi, p. 101.
1865. *Obolus, Obolella (Kutorgina)*, BILLINGS. Palæozoic Fossils, vol. i, pp. 6, 8.
1866. *Obolella?*, DAVIDSON. British Silurian Brachiopoda, p. 62.
1868. *Kutorgina*, DAVIDSON. Geological Magazine, vol. v, p 312.
1871. *Kutorgina*, DAVIDSON. British Silurian Brachiopoda, Appendix, p. 342.
1873 *Iphidea* (??), MEEK. Sixth Ann. Rept. U. S. Geological Survey Terr., p. 479.
1874 *Trematis?*, WHITE. Geogr. and Geol. Surv. West 100th Merid., Prelim. Rept., p. 6.
1875. *Trematis?*, WHITE. Geogr. and Geol. Surv. West 100th Merid., Final Rept., vol. iv, pt. i, p. 36.

1876. *Kutorgina*, LINNARSSON. Brachiopoda of the Paradoxides Beds of Sweden, p. 25.
1877. *Kutorgina*, HALL and WHITFIELD. U. S. Geological Exploration Fortieth Parallel, p. 207.
1883. *Kutorgina*, DAVIDSON. British Silurian Brachiopoda, Supplement, p. 212.
1884. *Kutorgina*, WALCOTT. Paleontology Eureka District, pp. 18–21.
1885. *Kutorgina*, MATTHEW. Illustrations of the Fauna of the St. John Group, No. 3, p. 42.
1886. *Kutorgina*, WALCOTT. Bulletin No. 30, U. S. Geological Survey, pp. 101–107.
1887. *Kutorgina*, WALCOTT. American Journal of Science, vol. xxxiv, p. 190.

This genus was founded by Mr. BILLINGS on certain obelloid fossils which he had previously referred to the genus OBOLELLA. In a foot-note to his description of the species *Obolella cingulata*, he suggested* the deviation of this form from *O. chromatica*, in the elevation of the beak of the dorsal valve, which in his judgment implied an area and probably a foramen. The muscular impressions were indicated as "two large, oval impressions faintly impressed, but still distinctly visible" with "no trace of the lateral scars." The name KUTORGINA was proposed in the event of this species not proving congeneric with *O. chromatica.*

Among subsequent students of these fossils, no one has given so thorough a discussion of their characters, or has had access to such complete material, as Mr. C. D. WALCOTT. We therefore present the diagnosis of the genus as formulated by him.†

"Shell inequivalve, transverse or elongated: hinge-line extended nearly to the width of the shell.

"Larger or ventral valve convex, elevated at the beak, which is straight or incurved, with or without a mesial sinus; area narrow, or without a true area; when present it is divided by a wide open fissure. Smaller or dorsal valve flat or slightly convex, beak marginal.

"The areas of both the ventral or dorsal valves of the species which we have showing them, are very narrow, and the fissure between them broad and relatively large. A number of thin longitudinal sections, cut so as to cross the beak, and also out on the cardinal edges, fail to show any covering to the fissure, and the area appears a little more than the reflexed shell, as the lines of growth of the valve extend over and upon it.

"Exterior of valves marked by concentric striæ or lines of growth that terminate on the cardinal edges of the valves, as in *K. cingulata;* nearly smooth

* Geology of Vermont, p. 948. 1861; Palæozoic Fossils, vol. i, p. 9. 1865.
† Bulletin No. 30, U. S. Geological Survey, pp. 101, 102.

and shiny, as in *K. Labradorica*; like that of TREMATIS, *K. pannula*, or LINGULELLA, *K. sculptilis*.

"The interiors of the valves of the only species we have showing the interiors, *K. cingulata*, have numerous radiating striæ extending from the beak outward toward the margins of the shell.

Kutorgina cingulata.
After WALCOTT
FIGS. 47, 48 Brachial and profile views.
FIGS. 49. Interior of a brachial valve.

"In the interior of the ventral valve four pairs of scars extend from the beak forward as shown in figure 1 *d*, pl. ix.

"The interior of the dorsal valve is divided midway by a narrow mesial ridge that separates two pairs of scars [adductors ?]; the anterior pair small.

"Shell-structure calcareous (*K. cingulata*, *K. Whitfieldi*), or horny (*K. Labradorica*, *K. sculptilis*)."

Type, *Kutorgina cingulata*, Billings.

Although the foregoing diagnosis furnishes many details of this group of shells, it must be admitted that it is still insufficient to establish a satisfactory comprehension of the generic characters or taxonomic position of KUTORGINA. Specimens of *K. cingulata*, from Swanton, Vermont, *K. Latourensis*, from Portland, N. B., and *K. Prospectensis*, from Lone Mountain, Nevada, which have been at our disposal, fail to add any features of importance.

In this genus we meet shells often of considerable size when compared with the associated brachiopods in primordial faunas, having in the type-species at least, a high, incurved pedicle-valve with the form of an AMBOCŒLIA, and a subapical slope ("false cardinal area"), which, according to WALCOTT,* is "without the trace of an opening," although this feature does not agree with the diagnosis above given, nor with the characters of the subapical area in other species referred to the genus, where the open fissure appears to begin at the apex and widen downwards, having very much the character seen in the genus ORTHIS. The opposite valve, with its highly elevated marginal apex and very slightly developed area, can come into contact with the pedicle-valve only at

* Bulletin No. 30, U. S. Geological Survey, p. 103.

the extremities of the cardinal line, thus leaving a great gap between the valves, into which the pedicle-fissure merges.

This feature, if established, is without an homologue among the brachiopods, although its function may be regarded as a means of passage for the pedicle similar to that found in all the biforate articulated brachiopoda. It does not appear from the descriptions of other species of KUTORGINA that the brachial valve is as elevated as in *K. cingulata*, but it is yet to be ascertained how far the apparent flatness of this valve has been due to pressure in fossilization. Mr. MATTHEW, in the description of his species, *K. Latourensis*,* has mentioned the existence of "a minute tooth on each side of the very narrow and small foraminal opening." But this important character requires verification, for not only are the St. John specimens of KUTORGINA small and fragile, but have usually been subjected to more or less distortion, which might readily develop irregularities easily mistaken for permanent features.

The general character of the umbonal region in the pedicle-valve would indicate a certain degree of similarity in KUTORGINA and ACROTRETA. In the latter genus the furrow on the cardinal slope appears to have been due to the closing of the pedicle-aperture by the progressive accretions to the shell, involving a modification of the surface and its concentric growth-lines: while in KUTORGINA the primitive apical aperture has been left unclosed.

The internal or muscular impressions are also imperfectly known and at present furnish no assistance in establishing the affiliations of the genus.

A very close ally of KUTORGINA, in size and all external features except the cardinal characters of both valves, is the Russian genus VOLBORTHIA, von Möller (*q. v.*). The latter has full, rounded umbones on both valves, and the high area of the pedicle-valve is crossed, not by an open fissure, but by a convex ridge; the shell is described as having no foramen. The beak of the brachial valve lies close against the cardinal edge of the opposite valve, leaving no hiatus as in KUTORGINA.

Under the notice of the genus SCHIZOPHOLIS, Waagen, we have referred to the similarity of its type-species and *Kutorgina Latourensis*, Matthew.

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* Illustrations of the Fauna of the St. John Group, No. 3, p. 42 1885.

Of KUTORGINA the following species have been described by American authors: *K. cingulata*, Billings (*loc. cit.*); *K. sculptilis*, Meek (*Iphidea?? sculptilis*, Meek, referred to KUTORGINA by Mr. WALCOTT*); *K. pannula*, White (*Trematis? pannulus*. White, referred to KUTORGINA by Mr. WALCOTT†); *K. minutissima*, Hall and Whitfield;‡ Mr. WALCOTT§ makes this name a synonym for *K. sculptilis*; *K. Prospectensis*, Walcott;‖ *K. Whitfieldi*, Walcott;¶ K. *Labradorica*, Billings,** = *Obolus Labradoricus*. Billings, referred to KUTORGINA by Mr. WALCOTT; *K. Latourensis*, Matthew;†† *K. pterineoides*,‡‡ Matthew.

In 1868, DAVIDSON identified the species *Obolella Phillipsi*. Holl, from the Lingula Flags and Lower Tremadoc. as *K. cingulata*, Billings, and in 1876, LINNARSSON described from the Paradoxides beds of Sweden a similar form as *K. cingulata* var. *pusilla*.

All the representatives of this genus known are from primordial faunas.

GENUS SCHIZOPHOLIS, WAAGEN. 1885.

1885. *Schizopholis*, WAAGEN. Mem. Geol. Surv. India. Palæontologia Indica: Ser. xiii, Salt-Range Fossils, I. Productus-limestone Fossils; iv (fas. 5), Brachiopoda, p. 752.

"The shells belonging to this genus are all of very small size. They consist of two valves, of which one is imperforated and rather flat, the other is slightly elevated with a somewhat prominent marginal apex, below which is a small triangular area slit open in the middle by a triangular fissure, which seems to be sometimes a little widened at the top, forming a kind of foramen, placed just at the extremity of the apex.

"The shell-surface is finely granular, and it seems as if it had borne spine-like appendages as in SIPHONOTRETA, but these are not preserved in any of the specimens at my disposal.

"Of the internal characters of the genus nothing is known to me, as there are only three specimens available; and as the rock, a black micaceous shale,

* Palæontology Eureka District, p. 20.

† Bulletin No. 30, U. S. Geological Survey, p. 105.

‡ U. S. Geological Exploration Fortieth Parallel, vol. iv, p. 207, pl. i, figs. 11, 12.

§ Palæontology Eureka District, *loc. cit.*

‖ Palæontology Eureka District, p. 19, pl. ix, figs. 1 a, b.

¶ Palæontology Eureka District, p. 18, pl. ix, figs. 4, 4 a.

** Palæozoic Fossils, vol. i, p. 6.

†† Illustrations of the Fauna of the St. John Group, No. 3, p. 42, pl. v, figs. 18 a–e.

‡‡ Illustrations of the Fauna of the St. John Group No. 3, p. 43, pl. v, fig. 19.

adhered very firmly to the internal side of these shells, it appeared impossible to make a preparation of the inside." (Waagen, *ut. cit.*)

Type, *Schizopholis rugosa*, Waagen, pl. lxxxvi, figs. 2–4. Obolus Beds, Salt Range = Primordial.

This genus, represented by a single species, is placed by Dr. Waagen, with unquestioned accuracy, among the Siphonotretids. Its closest alliance is with Kutorgina, or with those species of that genus which have afforded definite evidence of an open fissure on the subapical area, *i. e.*, *K. Latourensis*, Matthew, *K. pannula*, White. This feature has already been given among the generic characters of Kutorgina, but it may be held subject to reservation, since positive evidence of its existence in the type-species, *K. cingulata*, Billings, is still wanting. The resemblance between *K. Latourensis* and *Schizopholis rugosa* is most striking in every essential respect, and should the former not prove congeneric with *K. cingulata*, it must be referred to Schizopholis; conversely, if these species are congeneric, it would appear that Schizopholis must be considered a synonym for Kutorgina.

Schizopholis rugosa
After Waagen
Fig. 50. Pedicle valve, front view
Fig. 51 Cardinal view

Genus VOLBORTHIA, von Möller 1873.

1847. *Acrotreta*, Kutorga. Verhandl. Kais. Mineral. Gesellsch. zu St. Petersburg, p. 277, pl. vii, fig. 9.
1873. *Volborthia*, von Möller. Verhandl. Kais. Mineral. Gesellsch. zu St. Petersburg, pl. vii, fig. 9.
1874. *Volborthia*, von Möller. Neues Jahrb. für Mineralogie, etc., Heft 5, p. 449, pl. vii, figs. 1–6.

Type, *Acrotreta recurva*, Kutorga. Lower Silurian (= Primordial ?).

The genus is founded on the third of Kutorga's species of his genus Acrotreta, a form of very large size compared with the type of the genus. Kutorga's description covers only a single pedicle-valve, from which the apex was broken. The better examples described by von Möller show that the shell-substance is calareo-corneous and finely punctate. In general form the shell suggests a "cornucopia, the mouth of which is

Volborthia recurva.
After von Möller
Fig. 52 Profile
Fig. 53 Cardinal view.

closed by a very convex cover. Viewed from above, the outline of the shell is transversely oval, the posterior margin, the length of which has about one-half the diameter of the shell, being straight. The ventral valve is elevated and conical, and possesses an incurved and inflated umbo with no foramen. Between the beak and the posterior margin is a sharply defined, elevated, triangular area, which is divided by a low, convex ridge passing from the beak to the margin.

"The dorsal valve is convex, though much more depressed than the ventral, and has a beak similar to that of the latter. Although this beak lies in the same vertical line with that of the opposite valve, it rests directly upon the posterior margin of the valve, and has no area. The surface of the valves is smooth and covered only by fine concentric lines, which are continued without interruption over the area of the ventral valve. * * * * *

"Neither valve appears to possess any internal apophyses, at least the internal casts show no trace of them. The muscular impressions are unknown, the casts showing only a small number of widely divergent radiating lines." (VON MÖLLER, *ut. cit.*)

The similarity of this shell to KUTORGINA in general form and surface-features, is at once apparent. We meet, however, a conspicuous difference in the areal ridge of VOLBORTHIA, a feature strongly suggestive of the "pseudo-deltidium" of the articulate brachiopods. It is precisely similar to the areal ridge in IPHIDEA, and the exact counterpart in form of the areal furrow in ACROTRETA; its origin may be similarly explained, and a complete analogy may be found, in this respect, in the genera with the foramen-scar ecurved as in VOLBORTHIA and IPHIDEA, incurved as in ACROTRETA and CONOTRETA, and open as in KUTORGINA and SCHIZOPHOLIS. While we must admit the absence of an external foraminal aperture in the material so carefully studied and satisfactorily illustrated by Professor VON MÖLLER, we are led to surmise that this character, often so obscure and difficult of detection in such fossils, will eventually be found. The shells of VOLBORTHIA, like those of KUTORGINA, are of very considerable size, an example cited having a length of 14 mm., a width of 19 mm. and a height of 16 mm.

Genus IPHIDEA, Billings. 1872.

PLATE IV, FIGS. 6-9.

1872. *Iphidea*, Billings. Canadian Naturalist, New Series, vol. vi, p. 177.
1874. *Iphidea*, Billings. Palæozoic Fossils, vol. ii, pt. i, p. 76.
1876. *Iphidea*, Linnarsson. Brachiopoda of the Paradoxides Beds of Sweden, p. 25.
1886. *Iphidea*, Walcott. Bulletin No. 30, U. S. Geological Survey, p. 100.

Diagnosis. "Of this genus we have no specimens showing the internal structure, but the external characters seem sufficient to separate it from any described generic group. The ventral? valve of *I. bella* is conical, strongly elevated at the beak, hinge-line nearly straight, posterior angles narrowly rounded, sides and front nearly uniformly rounded, forming rather more than a semicircle. Posterior side with a large false area and a convex pseudo-deltidium, the width of which at the hinge-line is nearly one-third the whole width of the shell. The dorsal valve is semicircular, moderately convex, most elevated at the beak The hinge-line appears to be straight. * * * The surface is covered with fine concentric striæ, which in the ventral valve are continued around on the area."*

Type, *Iphidea bella.*

The foregoing diagnosis is derived from the original description of the type-species, *Iphidea bella.* After the lapse of eighteen years since the date of its publication little has been contributed to our knowledge and no facts of essential importance bearing upon the external characters of these shells; of the interior we still know nothing. In 1873, Mr. Meek described the species *Iphidea (??) sculptilis*,† from the Gallatin River, Montana, but as the hinge-line and subapical area of the shell have not been observed, and on account of its apparent specific identity with the *Kutorgina minutissima*, Hall and Whitfield, it has been referred provisionally to the genus Kutorgina by Mr. Walcott, and the latter species reduced to a synonym.‡ Dr. Linnarsson described the species *I. ornatella*, from the Paradoxides beds,§ giving good figures of the exterior of

* Billings. Canadian Naturalist, 1872, *loc. cit.*

† Preliminary Palæontol. Rept.: Sixth Ann. Rept. U. S. Geological Survey Terr., p. 479.

‡ Palæontology Eureka District, p. 20.

§ Brachiopoda of the Paradoxides Beds of Sweden: Bihang till K. Svenska Vet Akad. handlingar, Bnd. 3, No. 12, p. 25, pl. iii, figs. 42, 43.

both valves, and it would be difficult to indicate essential differences in the general form and proportions of this species and *I. bella.**

Notwithstanding the fact that our knowledge of these shells is so circumscribed, certain of their features are of definite generic value.

Fig. 54. *Iphidea bella.* After Billings.

The apical foramen indicates the close alliance of the genus with Acrotreta and Acrothele, and may be considered as an intermediate stage in the forward progress of the pedicle-aperture from its intermarginal position in the linguloids and oboloids, to its excentric position and tubular character in Schizambon. The flattened subapical slope is a feature also seen in Acrotreta, while the convex foraminal covering on this area, which gives to the shell an appearance so suggestive of Orthisina, is found in the inarticulate brachiopods only here and in Volborthia. The shell-substance is corneous, apparently consisting of but few layers.

The originals of Mr. Billings' *I. bella* were from Trois Pistoles, near Quebec; "a closely allied species of the same genus occurs in the primordial limestone at Topsail Head, Conception Bay, Newfoundland" (Billings, *loc. cit.*). The specimen here figured on Plate IV (figs. 8, 9), is from Georgia, Vermont. We have before us specimens of a species from the Grand Cañon, Arizona (Tonto group of Walcott = Potsdam sandstone ?), which bears a more prominent areal ridge than *I. bella*, and has the cardinal edge elevated above the rest of the margin of the valve, a feature strongly marked in Linnarsson's species, *I ornatella.*

Genus ACROTHELE, Linnarsson. 1876.

PLATE III, FIGS. 25 31.

1868. *Lingula*, Hartt. Dawson's Acadian Geology, Second Edition, p. 644.
1876. *Acrothele*, Linnarsson. On the Brachiopoda of the Paradoxides Beds of Sweden, p. 20.
1879. *Obolus ?*, Barrande. Système Silurien du Centre de la Bohême, vol. v, pl. 102, fig. vii.
1879. *Discina*, Barrande. Système Silurien du Centre de la Bohême, vol. v, pl. 110, fig. vii.
1881. *Acrothele*, White. Proceedings United States National Museum, vol. iii, p. 47.
1883. *Acrothele*, Davidson. British Silurian Brachiopoda, Supplement, p. 214.
? 1884. *Acrothele ?*, Walcott. Palæontology Eureka District, p. 14.
1884. *Acrothele*, Walcott. Bulletin No. 10, United States Geological Survey, p. 15.

* Mr. Walcott has promised additional details in regard to this genus (Bulletin No. 30, U. S. Geological Survey, p. 100), which will be looked for with interest.

1885. *Acrothele*, MATTHEW. Transactions Royal Society of Canada, Section iv, p. 39.
1886. *Acrothele*, WALCOTT. Bulletin No. 30, United States Geological Survey, p. 107.

DIAGNOSIS. "Shell corneous, composed of several laminæ, the inner smooth and polished, the outermost one rough and opaque. Ventral valve slightly conical, with excentric umbone, pierced by a minute foramen, in front of which there are, at least in one species, two small wart-like protuberances; the field between the umbone and the posterior margin is usually a little flattened, thus forming a slight indication of a false area. Dorsal valve with marginal umbone, consisting of two wart-like protuberances. In the interior of the dorsal valve there are two oblong, diverging muscular scars, close to the posterior margin, and two small rounded scars near the middle. The muscular scars are separated by a longitudinal ridge."*

Type, *Acrothele coriacea*, Linnarsson.

OBSERVATIONS. With the interior characters of this genus and those of the closely related group ACROTRETA imperfectly known, the essential distinction at present recognizable in the two is in the relative development of the subapical slope. This feature in ACROTRETA is often very conspicuous, producing strikingly conical shells which have their apices truncated by the foraminal opening and the posterior moiety of the surface nearly vertical. In ACROTHELE the foramen in the pedicle-valve is also apical, but the slope from the apex to the posterior margin is gentle, often scarcely defined. The small wart-like protuberances lying in front of the foramen, as indicated by LINNARSSON for the type-species,† and also seen in the accompanying figures of *A. Matthewi*, Hartt (Plate III, figs. 25–29), have been made from the illustrative specimens used by Mr. MATTHEW.‡ Though the function of these bodies may not be understood, they appear to be homologues of the apical callosity in ACROTRETA (*e. g.*, *A. Baileyi*, Matthew), and the mammiform swelling about the foramen in SIPHONOTRETA. In the interior of the brachial valve, the most persistent feature, as far as observed, is the axial ridge, which is sometimes accompanied by faint diverging muscular ridges on either side near the beak (*A. Matthewi*), dividing the halves of an obscure circumbonal muscular impression.

* LINNARSSON. On the Brachiopoda of the Paradoxides Beds of Sweden, p. 29.
† LINNARSSON. On the Brachiopoda of the Paradoxides Beds of Sweden, pl. iv, figs. 41*b*, 19*b*.
‡ Transactions of the Royal Society of Canada, pl. v. 1885.

In *A. coriacea* LINNARSSON found small circular scars in the middle of this valve, abutting closely against the median septum. The septal characters seen in the two species mentioned are also shown in WALCOTT's figures of *A. subsidua*, White.* Mr. MATTHEW has described some features of the hinge-line as follows: "Just within the posterior margin [of the pedicle-valve] there are four minute pits, of which the two inner correspond to small tooth-like projections of the dorsal valve; the two outer ones are opposite the posterior ends of the comma-shaped grooves of the umbonal depression."† We are not confident that we have been able to detect these characters satisfactorily on Mr. MATTHEW's typical specimens, but the suggestion has already been made that with fossils as liable to distortion and imperfect preservation as these frail bodies, great caution is needed in the separation of permanent and fugitive features.

The shell-substance in this genus is essentially corneous and, as observed by LINNARSSON, is composed of several laminæ. The surface is usually devoid of other ornamentation than concentric growth-lines, but in *A. granulata*, Linnarsson, *A. subsidua*, White, and *A. Matthewi*, Hartt, the concentric lines are more or less interrupted, producing a granular or papillate appearance.

The known species of ACROTHELE are few, and all its American representatives belong to primordial faunas. In 1874, Dr. WHITE described, under the name *Acrotreta? subsidua*,‡ a species from Antelope Springs, Utah, which he subsequently (1880, *loc. cit.*) referred to ACROTHELE. Mr. WALCOTT, in 1884,§ referred to this genus the *Lingula Matthewi* of HARTT, from the St. John group,‖ and, in the same year, described the species *Acrothele? dichotoma*,¶ from the Prospect Mountain group of Nevada. This species, however, bears a very distinct subapical slope, and was subsequently transferred by its author to the genus ACROTRETA.** Of the two species described by LINNARSSON, *A. coriacea* and *A. granulata*, the latter has been reported by Dr. DAVIDSON, from the Upper

* Bulletin No. 30, United States Geological Survey, pl. ix, figs. 4 a, 4 c.

† Transactions of the Royal Society of Canada, p. 40. 1885.

‡ Geographical and Geological Exploration West of 100th Meridian: Prelim. Rept. Invert. Foss., p. 6.

§ Bulletin No. 10, United States Geological Survey.

‖ Mr. MATTHEW has designated two varieties of this species: (*a*) *prima*, (*b*) *lata*.

¶ Palæontology Eureka District, *loc. cit.*

** Bulletin No. 30, United States Geological Survey, p. 107.

Llandeilo at Coal-pit Bay, county Down, Ireland. This is a species which it is manifestly difficult to separate from either *A. subsidua* or *A. Mattheri* by any external or internal characters.

The *Obolus ? Bohemicus*, Barrande,* from the Etage C, and *Discina secedens*, Barrande,† from the Etage D, appear to belong to this genus. BARRANDE'S figures of the latter species show very distinctly the two tubercles or callosities lying in juxtaposition to the inner opening of the foramen.

GENUS ACROTRETA, KUTORGA. 1848.

PLATE III, FIGS. 32-34

1848. *Acrotreta*, KUTORGA. Verhandl. der russ.-kais. mineral. Gesellsch. zu St. Petersburg, p. 275.
1853. *Acrotreta*, DAVIDSON. Introduction British Fossil Brachiopoda, p. 133.
1865. *Acrotreta*, VON SEEBACH. Zeitschr. der deutsch. geolog. Gesellsch., vol. xvii, p. 341.
1865. *Acrotreta*, BILLINGS. Palaeozoic Fossils, vol. i, p. 216.
1871. *Acrotreta* (?), DAVIDSON. British Silurian Brachiopoda, p. 343.
1872. *Acrotreta*, MEEK. Sixth Ann. Rept. U. S. Geological Survey Terr., p. 463.
1874. *Acrotreta*, WHITE. Geographical and Geological Exploration and Survey West 100th Meridian: Prelim. Rept Invertebrate Fossils, p. 9.
1875. *Acrotreta*, WHITE. Geographical and Geological Exploration and Survey West 100th Meridian: Final Rept., vol. iv, pt. 1, p. 53.
1876. *Acrotreta*, LINNARSSON. Brachiopoda of the Paradoxides Beds of Sweden, p. 16.
1883. *Acrotreta*, DAVIDSON. British Silurian Brachiopoda, Supplement, p. 213.
1884. *Acrothele?*, WALCOTT. Palæontology of the Eureka District, p. 14.
1885. *Acrotreta*, MATTHEW. Illustrations of the Fauna of the St. John Group, No. 3, p. 36.
1886. *Acrotreta*, WALCOTT. Bulletin No. 30, United States Geological Survey, p. 98.

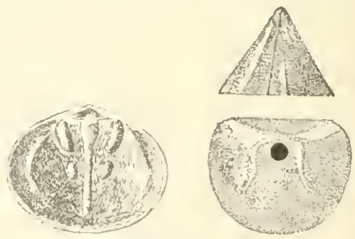
DIAGNOSIS. "Dorsal [pedicle-] valve conical; the cardinal face of the cone flat, having a triangular form and resembling a cardinal area. From the apex to the center of the base of this area runs a shallow groove, which may be taken as an indication of a deltidium. At the upper extremity of this groove is the suboval external opening of the sipho, which is inclined toward the cardinal side. Ventral [brachial] valve flat, with a distinct marginal apex. Upon the external surface of the shell are only delicate concentric growth-wrinkles, which are continued over the groove on the cardinal surface: no tubercles or spines. Cardinal margin straight." ‡

Type, *Acrotreta subconica*, Kutorga.

* Système Silurien Bohême, vol. v, pl. 102, fig. vii; 1, 2, 3.
† Système Silurien Bohême, vol. v, pl. 110, fig. viii.
‡ KUTORGA, *loc. cit.*

KUTORGA described three species of this genus, of which the foregoing is the first. The others, *A. disparirugata* and *A. recurva*, vary considerably from the type-species in the degree of incurvature of the high pedicle-valve, and in the definition of the subapical area and the groove upon its surface, so that it will be important to establish the conception of the genus strictly upon the features of the first species.* Externally these shells are most closely related to ACROTHELE, with which they agree in the relative positions of the umbones, and in the perforation of the pedicle-valve. As observed under the discussion of that genus, the distinguishing character is found in the different elevation of the pedicle-valve, and the lack of any well defined subapical area in the latter genus.

Until the studies of Mr. WALCOTT and Mr. MATTHEW upon the American species of this genus were made public, nothing of importance was known in regard to its internal characters. The former writer, in 1884,† represented a cast of the interior of the pedicle-valve of *A. gemma*, with a somewhat broad excavation about the pedicle-aperture, which would give to the interior of the valve an apical swelling or callosity, penetrated by the foramen. Mr. MATTHEW, in 1885, gives a figure of the interior of this valve in *A. Baileyi*,‡ showing the same character with the addition of two pits (tubercles) close upon, but just in front of the foraminal opening. If this latter feature can be established it furnishes another similarity to ACROTHELE; but, with the original specimen in our hands, we must confess our inability to distinguish anything more than the impression of the central callosity (Plate III, figs. 32, 34). Mr. WALCOTT's figure shows elongate muscular scars surrounding the foramen and diverging forward. The interior of the brachial valve of *A. gemma* (WALCOTT's figure 1 *a*; "ventral valve" in error), shows a stout median ridge, which is widened near the apex of the valve and



Acrotreta gemma.
After WALCOTT.
FIG. 55. Interior of brachial valve.
FIG. 56. Cardinal view of pedicle-valve.
FIG. 57. Internal cast of apical portion.

* *Acrotreta recurva*, Kutorga, has been taken by VON MÖLLER as the type of the genus VOLBORTHIA (*q.v.*)
† Palæontology of the Eureka District, pl. i, figs. 1 *a*. *f*.
‡ Illustrations of the Fauna of the St. John Group, No. 3, pl. v, fig. 13 *c*.

flanked by cardinal (?) scars, in front of which are two smaller impressions. Essentially the same features are seen in Mr. MATTHEW's figure* of the interior of this valve. The interior of the brachial valve of *A. gemma* is compared by Mr. WALCOTT to that of the *Obolella Sabrinæ*, Callaway, as represented by DAVIDSON.† The agreement is essentially complete in these respects, and Mr. DAVIDSON's figures of the pedicle-valve of this species give it a great elevation and an indistinct cardinal area, though they do not show the apical foramen. It is highly probable that the species will prove an ACROTRETA

Obolella Sabrinæ. After DAVIDSON.
FIG. 58. Internal cast of brachial valve.

Acrotreta Nicholsoni. After DAVIDSON.
FIG. 59. Interior of brachial valve.

The vertical groove on the cardinal area is, like the elevation and definition of the area itself, a very variable feature. In *A. subconica*, *A. gemma*, and *A. Nicholsoni* it is sharply defined, while *A. disparirugata*, Kutorga, *A. Baileyi* Matthew, and *A. socialis*, von Seebach, bear less definite indications of this character. The suggestion offered by KUTORGA, that this furrow may be taken as an "indication of a deltidium," may be understood as not implying more than a remote homology with the deltidium of the articulate brachiopods.

We have yet but few American representatives of this genus. In 1865, Mr. BILLINGS described the first known American species, *A. gemma*, and Mr. WALCOTT (1884) has considered the species regarded by MEEK (1872) as *A. subconica*, Kutorga,‡ from the Gallatin River, Montana, and the *A. pyxidicula*, White (1874), from Nevada, as synonymous with it. *Acrothele? dichotoma*, Walcott (1884), from Nevada, has been subsequently referred by its author (1886) to ACROTRETA, while *Acrotreta subsidua*, White (1874), is referred to ACROTHELE. Mr. MATTHEW has described (1885) *Acrotreta Baileyi* and *A.? Gulielmi*, from the St. John group: the latter of these is a representative of a distinct genus, which is discussed in the following pages under the name DISCINOPSIS. All the American species are from primordial faunas: *A. socialis*, von Seebach, is

* Illustrations of the Fauna of the St. John Group, No. 3, pl. v, fig. 13.

† British Silurian Brachiopoda, Supplement, pl. xvi, fig. 27d.

‡ This form Mr. MEEK proposed to name *A. attenuata*, in case it proved distinct from the Russian species.

from the Paradoxides Beds; *A. subconica* and *A. disparirugata*, Kutorga, from the primordial beds of Russia; *A. Nicholsoni* and *A. ? costata*, Davidson, from the Llandeilo. The last species is strongly ribbed on its exterior, but its generic relations are too uncertain to allow this fact to be regarded as adding a new feature to the genus.

Genus CONOTRETA, Walcott. 1889.*

PLATE IV K, FIGS. 16-21.

1889. *Conotreta*, Walcott. Proceedings National Museum, vol. xii, No. 775; Advance Sheet, Dec. 10.

Diagnosis. The pedicle-valve is conical, its height being greater than its length. The apex is more or less broken on all the specimens, but in a single minute valve from Covington, Kentucky, there is evidence of the external opening of the sipho. From the apex, a shallow furrow extends to the posterior margin, increasing in width downward. In the smaller specimens the posterior wall of the shell conforms to the curvature of the rest of the surface, interrupted only by the longitudinal depression, but, with increase in size, this area becomes distinctly flattened, as in Acrotreta. Surface covered with sharp concentric striæ which make a slight upward curve as they cross the foraminal groove.

The casts of the interior show a strong apical callosity surrounding the probable position of the foramen. This is somewhat produced anteriorly into a short sharp ridge, on either side of which lie two other ridges, with evidence of a third on the lateral slopes. Upon the largest of the specimens these ridges seem to have been hollowed at their extremities.

Type, *Conotreta Rusti*, Walcott.

* In a preliminary list of the genera of the palæozoic brachiopoda, published in the Eighth Annual Report of the State Geologist, 1889, p. 43, the term Geinitzia was used for this genus, a description of which had at that time been prepared from material in our hands, obtained from the Utica horizon at Covington, Kentucky. It would have been necessary to withdraw this name, as it had already been in use for a genus of fossil plants (Endlicher, Synopsis Coniferarum, p. 281. 1847). Meanwhile Mr. Walcott has described the genus from specimens from Trenton Falls, in an advance sheet of the Proceedings of the National Museum, privately circulated. We have been permitted to make use of his specimens for study and illustration.

OBSERVATIONS. These shells differ from ACROTRETA in their less distinctly defined posterior area and in the character of their internal markings. The apical callosity is much more prominently developed and the ridges radiating from it (two in ACROTRETA, according to WALCOTT*) more numerous. The lack of definition in the posterior subapical slope, apparent in the young shells from the Utica horizon at Covington and the Trenton limestone at Trenton Falls, suggests the condition of this feature in the genus MESOTRETA, and also in the species figured by M. BARRANDE,† from the Etage D, under the name, *Acrotreta Babel*, which has an elevated, conical pedicle-valve with a perforated apex and unspecialized posterior slope.

GENUS DISCINOPSIS, GEN. NOV. (MATTHEW).

PLATE III, FIGS 20 21

1885. *Acrotreta ?*, MATTHEW. Illustrations of the Fauna of the St. John Group, No. vi, p. 37.

From the examination of the original specimens of Mr. MATTHEW'S species, *Acrotreta ? Gulielmi*, from the St. John group, at Portland, N B., it has become evident that the internal impressions, especially those of the perforated valve, are of a character widely different from those of ACROTRETA, or, indeed, of any of the allied genera. Upon expressing this conviction to Mr. MATTHEW with the request for any additional material that might throw light on this rather obscure shell, he kindly placed at our disposal all his specimens of the species, and in accordance with our suggestion that it represented a new generic form and would hence require a new name, has proposed for it the term DISCINOPSIS.

DIAGNOSIS. Shell subcircular in outline. Surface depressed-conical, apices excentric, not marginal. Pedicle-valve with the apex truncated by a circular foraminal aperture (?). The interior of this valve is characterized by a pair of deep, diverging furrows, passing forward from the beak or internal foraminal opening, in broad curves which converge toward the anterior margin but without meeting. These furrows enclose a thickened and somewhat elevated central area, which, in the subumbonal region is apparently free, projecting for a short

* Palæontology of the Eureka District, pl. i, fig. 1 *b*.

† Système Silurien Bohême, vol. v, pl. 95, fig. vii. 1879.

distance, like a narrow, triangular shelf, beneath which the foramen probably opened. The interior opening of the foramen is, however, not apparent on any of the specimens examined, for, as usually preserved, the matrix has adhered to this subapical cavity, and in a single example only, is the shelf-like character of the median area distinctly demonstrated. A faint longitudinal ridge passes from the apex of the shelf to the anterior margin, but no other markings are discernible on the interior except faint radiating or slightly undulating, probably vascular lines.

The interior of the brachial valve, as far as known, shows no other characters than the radiating lines, which appear to belong to the ornamentation of the external surface.

Shell-substance tenuous, apparently corneous. External surface covered with more or less prominent, sometimes lamellose concentric growth-lines, crossed by fine, gently curved, radiating striæ which are usually more prominent when the concentric lines are exfoliated.

Type, *Discinopsis Gulielmi*, Matthew.

The nearest alliances of this peculiar and imperfectly known fossil appear to be with the genus LINNARSSONIA; both having the apical shelf or callosity in the pedicle-valve, but in the latter this is more elevated and concentrated posteriorly. In other respects, DISCINOPSIS differs from this genus, as well as from ACROTHELE, in the other internal markings and in the excentric apex of the brachial valve, while it is removed from ACROTRETA by these features and also by the absence of a subapical area. The deep furrows in the pedicle-valve may be compared to the pair of muscular (?) furrows diverging from the foraminal opening in *Acrotreta gemma*, as shown by WALCOTT.* One of the figures given by this author under the designation, *Linnarssonia Taconica*,† appears to represent a form of DISCINOPSIS.

* Palæontology of the Eureka District, pl. i, fig. 1 *b*.

† American Journal of Science, vol. xxxiv, pl. i, fig. 18 *a*. 1887.

Genus LINNARSSONIA, Walcott. 1885.

PLATE III, FIGS. 35-41

1866. *Obolella, Discina.* SALTER. Rept. British Association for 1865, p. 285.
1868. *Obolella.* DAVIDSON. Geological Magazine, vol. v, p. 309.
1868. *Obolella.* HARTT. Dawson's Acadian Geology, Second Edition, p. 644.
1871. *Obolella (partim).* DAVIDSON. British Silurian Brachiopoda, p. 339.
1876. *Obolella.* LINNARSSON. Brachiopoda of the Paradoxides Beds of Sweden, p. 19.
1885. *Linnarssonia.* WALCOTT. American Journal of Science, vol. xxix, p. 115.
1885. *Linnarssonia.* MATTHEW. Illustrations of the Fauna of the St. John Group, No. 3, p. 35.
1887. *Linnarssonia.* WALCOTT. American Journal of Science, vol. xxxiv, p. 189.
1889. *Linnarssonia.* DAWSON. Transactions Royal Society of Canada.

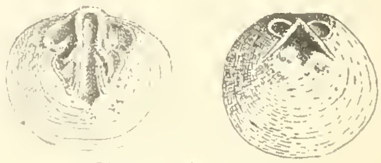
DIAGNOSIS. "Shell calcareous, transversely or longitudinally ovate, subcircular; convex in the typical species; valves inarticulate. Ventral valve convex, with the excentric apex perforated by a minute foramen; no area; cardinal edge thin. Dorsal valve convex in the species thus far known; without any area. In the interior of the ventral valve two oval and oblique scars lie each side of the slightly raised rim surrounding the minute foraminal opening and close to the posterior margin; from the foraminal rim a groove extends obliquely forward and outward on each side, so as to enclose a projecting Λ-shaped ridge that is highest at its posterior margin just in front of the circular foraminal opening. In the interior of the dorsal valve two large, irregularly circular scars are situated close to the posterior margin, and separated by a low, flat ridge that extends forward, between the two small divaricator scars."*

Type, *Obolella transversa*, Hartt.

OBSERVATIONS. The illustrations of the internal characters of this genus, which have been given with great elaboration by Mr. DAVIDSON,† for *Obolella sagittalis*, Salter, and also with instructive figures, by Dr. LINNARSSON,‡ for the same species; by Mr. WALCOTT, for the type of the genus,§ *L. transversa*, Hartt, and for *L. Taconica*, Walcott,‖ and by Mr. G. F. MATTHEW,¶ for the species *L. transversa*, Hartt, and *L. misera*, Billings, all produce the impression

* WALCOTT. American Journal of Science, vol. xxix, p. 115.
† Geological Magazine, vol. v, pl. xv, figs. 17-24; Silurian Brachiopoda, pl. l, figs. 1-14.
‡ Brachiopoda of the Paradoxides Beds, pl. iii, figs. 36-41.
§ American Journal of Science, 1885, vol. xxix, p. 116.
‖ American Journal of Science, 1887, pl. i, figs. 18 *b-d*.
¶ Illustrations of the Fauna St. John Group, 1885, pl. v, fig. 11 *a-e*, 12 *a-*

that the generic characters are not only very distinctly defined, but are of such a nature as to remove all these forms widely from OBOLELLA and its immediate allies. This is seen in the character of the muscular impressions alone: the absence of the great lateral scars, the broad, composite centrals, and the deep pedicle-pit of the ventral valve, all of which are indicial features of the obolelloid genera: furthermore there is no evidence of any cardinal area or anything more than a somewhat flattened margin of contact in either valve. On the other hand there are present (in *L. sagittalis*) conspicuous cardinal scars in each valve, of similar character to the posterior adductors of CRANIA (as suggested by Mr. DAVIDSON, *loc. cit.*, p. 340), which, in *L. transversa* and *L. misera*, take the form of stout tubercles or bosses, situated just within the posterior margin; and a mammiform or subtrihedral apical tubercle, which is perforated by a minute foramen (see Plate III, figs. 35, 37–39, 43). This feature was not represented in Mr. DAVIDSON's figures of *Obolella sagittalis*, but was first pointed out by LINNARSSON (*loc. cit.*), and is clearly seen in well preserved specimens. The character of the pedicle-aperture is of itself of sufficient significance to remove these species from the vicinity of OBOLUS and OBOLELLA, where this opening is always a groove on a well defined cardinal area, and to endorse its association with ACROTRETA, ACROTHELE, SCHIZAMBON, and the other allies of SIPHONOTRETA. The posterior submarginal tubercles or bosses have undoubtedly served as fulcra, probably of the adjustor rather than of the adductor muscles, acting to keep the valves in place, and they may be compared to the articular bosses in the genera SPONDYLOBOLUS and BARROISELLA.



Linnarssonia sagittalis.
After DAVIDSON.
FIG. 60. Internal cast of pedicle-valve.
FIG. 61. Internal cast of brachial valve.

The brachial valve has a less conspicuous development of these tubercles, but they are distinctly seen in *L. transversa*, *L. sagittalis* and *L. Taconica*. Between them lies a strong axial septum, which is broadened over the central portion of the shell, and is accompanied for most of its length by a shorter and narrower ridge on either side, from each of which it is separated by a sharp furrow.

The substance of the shell, in all the specimens which have passed under our

examination, is as distinctly corneous as in LINGULA, and from the manner of exfoliation seen in the shells, is evidently composed of successive laminae. The more intimate structure of the shell-substance is yet to be ascertained.

The species of LINNARSSONIA thus far known are all from primordial faunas; *L. transversa*, Hartt, and *L. misera*, Billings (Matthews), from the St. John group; *L. Taconica*, Walcott, from the Taconic limestones in Washington county, N. Y.; *L. pretiosa*, Billings, from the Quebec group, at Little Metis and elsewhere in Canada; *L. sagittalis*, Salter, from the Menevian of St. David's and elsewhere in Wales, in the Paradoxides beds at Bornholm, Sweden, and at Mt. Stephen, British Columbia. The *Obolella maculata*, Hicks, from St. David's, will probably prove referable to this genus.

GENUS MESOTRETA. KUTORGA. 1848.

PLATE IV, FIG. 21

1848. *Siphonotreta (Mesotreta)*. KUTORGA. Ueber die Brachiopoden-Familie der Siphonotretaeae: Verhandl. der russ.-kais. mineral. Gesellsch. zu St. Petersburg. Jahrg. 1847, p. 271, pl. vii, fig. 4 *a, b, c*.

1871. *Siphonotreta*, QUENSTEDT. Petrefaktenkunde Deutschlands: Brachiopoden, p. 674, pl. 61, fig. 33.

DIAGNOSIS. Shell patelliform, depressed-conical; apex central, perforated by a foramen; no area or cardinal flattening. Surface ornamented by concentric growth-lines bearing spines. Pedicle-valve only known.

Type, *Siphonotreta tentorium*, Kutorga.

We have elsewhere referred to the fact that this name was provisionally proposed for a species representing one extreme of variation in the position of the pedicle-aperture, allowed under KUTORGA's diagnosis of the genus SIPHONOTRETA. Under the original limitations of the latter genus, this form must be excluded as not being congeneric with *S. unguiculata*. When MESOTRETA is better known, it may be found to represent an important connecting link between ACROTRETA and SCHIZAMBON.

Genus SIPHONOTRETA, de Verneuil. 1845.

PLATE IV, FIGS. 24-26, 37, 38.

1829. *Crania*, Eichwald. Zoologia specialis, vol. i, p. 274.
1840. *Terebratula*, Eichwald. Ueber das silurisch. Schichten-Syst. von Esthland; Journ. Nat. Heilkund. med.-chirurg. Acad St. Petersb., p. 138.
1842. *Terebratula*, Eichwald. Die Urwelt Russlands, Heft 2, p. 145.
1845 *Siphonotreta*, de Verneuil. In Murchison, de Verneuil and Keyserling's Géol. de la Russie d'Europe et des mont. de l'Oural. p. 286, pl. i, figs. 13, 14.
1848. *Siphonotreta (partim)*, Kutorga. Ueber die Brachiopoden-Familie der Siphonotretææ; Verhandl. russ.-kais. mineral. Gesellsch. zu St. Petersburg, p. 261, pls. vi, vii.
1849. *Siphonotreta*. Morris. Annals of Natural History, Ser. 2, vol. iv, p. 315.
1853. *Siphonotreta*, Davidson. Introd. British Fossil Brachiopoda, p. 131, pl. ix, figs. 261-270 (not 268).
1866. *Siphonotreta*. Davidson. British Silurian Brachiopoda, p. 75, pl viii, figs. 1-6.
1871. *Siphonotreta (partim)*, Quenstedt. Petrefaktenkunde Deutschlands; Brachiopoden, p.674, pl.61.
1877. *Siphonotreta*, Davidson. Geological Magazine, p. 13.
1883. *Siphonotreta*, Davidson British Silurian Brachiopoda, Suppl., p. 217, pl. xvi, figs. 31-33.

Diagnosis. Shell elongate-oval, inequivalve; valves inarticulated. Pedicle-valve the more convex, with a straight, elevated, conical, and perforated beak, the circular foramen opening at the apex and communicating with the interior of the shell by a tubular canal, which narrows slightly as it passes inward. No cardinal area or deltidium is present, the growth-lines passing between the beak and the posterior margin as elsewhere on the shell. Brachial valve depressed-convex: beak marginal; posterior margin regularly arched and thickened. Interior of pedicle-valve with muscular impressions confined to the umbonal region. Close alongside the opening of the sipho, just within the cardinal margin, lie two elongate scars which are accompanied on either side by broader, somewhat expanded or flabellate, simple and less distinct impressions. Directly in front of the middle pair lies a small central scar, in the axis of the shell, and at either side of it a transversely elongate impression. These latter impressions are distinctly separated from the former by a transverse ridge.

In the brachial valve the impressions are equally concentrated, the entire muscular area being bounded on its posterior margin by a prominent ridge which, at the sides, merges into a compound lateral scar. The central portion of the area is much depressed and is divided axially by a narrow ridge or septum.

Shell ornamented with concentric lines and ridges, the epidermal layer bearing hollow spines, which are distended at the base. Shell-substance calcareo-corneous, the layers beneath the epidermis being punctured by radiating and branching tubules. These layers are concentric and not parallel to the internal surface.

Type, *Siphonotreta unguiculata*, Eichwald.

OBSERVATIONS. The foregoing description, with some essential modifications, is derived from the diagnosis of SIPHONOTRETA, as given by DE VERNEUIL, KUTORGA and DAVIDSON. The term as used by these writers, especially by KUTORGA, has been allowed to include species which differ considerably in the position and structure of that feature of first importance, the pedicle-aperture, and these forms, under a proper conception of congeneric characters, it seems advisable to withdraw from the genus.

In KUTORGA's elaborate study of SIPHONOTRETA and its allied genera,* the position of the siphonal opening was considered as varying between the cardinal margin and the center of the valve. Strictly, however, the opening takes neither of these extreme positions in SIPHONOTRETA, for in no species known is the umbo of the pedicle-valve marginal, and therefore the aperture, which may be regarded as always truncating the beak, can not be marginal. For the species *Siphonotreta tentorium*, Kutorga, in which both apex and aperture are at the center of the valve, the author himself suggested the name MESOTRETA, and the term may be useful as designating a form intermediate between ACROTRETA and SIPHONOTRETA. Under the discussion of the genus SCHIZAMBON, reasons are given for provisionally adopting Mr. WALCOTT's suggestion, that such species as *Siphonotreta fissa*, Kutorga, in which the external opening of the siphonal tube is situated in front of the apex and connected therewith by a conspicuous groove, should not be regarded as congeneric with *S. unguiculata* and other forms in which this aperture is circular and apical. Although there is considerable difference in the size and external expression of the type-species of SCHIZAMBON (*S. typicalis*, Walcott,) and the Russian and Canadian representatives of *Siphonotreta fissa*, yet

* Ueber die Brachiopoden-Familie der Siphonotretææ, p. 261, pl vi, vii.

in the absence of an accurate understanding of the internal impressions, there appears to be no feature of generic value by which they may be separated; it must, however, be admitted that the resemblance in general form and proportions of these latter shells to the true SIPHONOTRETA is very close.

The American palæozoic faunas have yet furnished no thoroughly satisfactory representative of SIPHONOTRETA. Before us are two specimens of a form allied to, but probably distinct from the Canadian representatives of SCHIZAMBON (?), referred to on a following page, which have been collected by Mr. CHARLES SCHUCHERT and Mr. E. O. ULRICH, from the Trenton limestone at Minneapolis, Minnesota. One of these is an exterior mould, the other retains both valves, though the umbonal portion of the pedicle-valve has been broken, leaving no indication of the character of its foraminal aperture. The shell differs somewhat from the Canadian specimens in outline, being broader over the pallial region; the brachial valve shows a low longitudinal depression, the shell-substance is very thin, while in the other species referred to it is remarkably thick, and its lamellose structure conspicuously developed; the ornamentation of the surface consists, not of sharp, concentric lines, broadening to ridges toward the margin, but of fine, concentric, anastomosing wrinkles, which are interrupted over the body of the shell by the edges of the spiniferous lamellæ; the spines are comparatively short and sparse. Though recognizing the difficulties in the discrimination of species of SIPHONOTRETA, we are nevertheless disposed to regard the above-mentioned features as of specific value; and in the absence of evidence determining the character and position of the pedicle-passage, it seems judicious to leave the species for the present under the genus SIPHONOTRETA, with the designation, *Siphonotreta Minnesotensis*.

The internal features of this genus are not so precisely known as to permit the satisfactory determination of homologies with other genera. Dr. DAVIDSON'S figures of the interiors of both valves of *S. unguiculata*, published in the Geological Magazine for 1877, and reproduced upon our Plate IV, differ in some important particulars from the earlier figures given by KUTORGA, essentially in the absence of the nipple-like swelling in the umbonal region of the pedicle-

valve, about the opening of the sipho. This feature is seen in all of KUTORGA's illustrations of the interior and internal casts of *S. unguiculata*, and would find an equivalent in the umbonal swelling in ACROTRETA, ACROTHELE and LINNARSSONIA.

Of the muscular scars in this valve, the anterior probably represents the anterior adductors, and the long impressions on either side of the sipho, terminating in these anterior scars may be the progressive track left by them in the growth of the shell. In the opposite valve, DAVIDSON represents a transverse posterior ridge, suggestive of the crescent in TRIMERELLA, enveloping or ending in distinct terminal scars, in front of which follow composite laterals divided by a median ridge. KUTORGA's figures show a slight median septum separated by a furrow on either side from strong diverging ridges; features which are not widely different from the impressions in the corresponding valve of LINNARSSONIA.

The Russian species of SIPHONOTRETA (*S. unguiculata*, Eichwald, *S. fornicata*, Kutorga, *S. verrucosa*, Verneuil, *S. aculeata*, Kutorga, and (?) *S. conoides*, Kutorga), are from the Lower Silurian faunas of the Baltic provinces; *S. micula*, McCoy, *S. Scotica*, Davidson, are from the Llandeilo flags, while the latest known representative of the genus, *S. anglica*, Morris, is from the Wenlock.

GENUS SCHIZAMBON, WALCOTT. 1884.

PLATE IV, FIGS. 27-30, COMPARE FIGS. 31-36.

1884. *Schizambon*, WALCOTT. Monographs U. S. Geological Survey, vol. viii; Palæontology of the Eureka District of Nevada, p. 69, pl. i, fig. 3.

Compare:

1848. *Siphonotreta*, KUTORGA. Verhandl. russ.-kais. mineral. Gesellsch. zu St. Petersburg. Jahrg. 1847, p. 271, pl. vii, fig. 5.

1853. *Siphonotreta*, DAVIDSON. Introd. British Fossil Brachiopoda, pl. ix, fig. 268.

1883. *Siphonotreta*, WHITEAVES. Amer. Assoc. Advanc. Science, Montreal Meeting.

1883. *Siphonotreta*, DAVIDSON. British Silurian Brachiopoda, Supplement, p. 218.

1887. *Siphonotreta*, AMI. Ottawa (Canada) Naturalist, December.

DIAGNOSIS. "Shell ovate or oblong-oval, inequivalve; valves inarticulate; larger or ventral valve most convex, with a short obtuse beak at the cardinal margin. Foramen oblong, and opening on the summit of the valve; no area or deltidium; cardinal edge thin; smaller or dorsal valve nearly as convex as the

larger, slightly flattened along the median line. Structure calcareo-corneous, consisting of a nacreous outer layer with a closely attached inner calcareous layer. Both layers are thought to be punctured by scattered tubulæ. Surface smooth or with distinct lines of growth, and scattered spines apparently on the outer edges of the laminæ or lines of growth. The interior of the larger valve shows the oblong foramen in a slight elongate depression and a pair of muscular scars just in front of it on each side of a slight longitudinal depression; from near the beak on each side of the foramen a shallow, sharply defined depression extends obliquely outward. No other markings were observed. In the interior of the dorsal valve a pair of anterior central muscular scars terminate their path of advance from the beak, a slight rounded ridge rising on the central line; posterior to these a larger pair occur, and still beyond and more posterior a third pair; a narrow rounded ridge extending obliquely down from the beak on each side between the central and lateral scars." (WALCOTT, *loc. cit.*)

Type, *Schizambon typicalis*, Walcott.

OBSERVATIONS. This peculiar genus presents an additional phase in the variation in position of the pedicle-aperture. We have seen, in KUTORGINA, ACROTHELE, ACROTRETA, etc., the stages of transition from the marginal pedicle-slit of the obolelloids to the apical aperture in SIPHONOTRETA, a group in which the subapical area loses its specilization and the progressive pedicle-furrow or ridge. SCHIZAMBON has the foramen in front of the umbo, and by the advancing growth of the shell, the opening always remaining at the same relative distance from the margin, an external groove, tapering toward the beak, is left behind it. The affinity of this genus with SIPHONOTRETA is very close. In the type-species, the outline and contour is slightly different from that usually met with in SIPHONOTRETA, but the surface is minutely spiniferous, while in *Siphonotreta fissa*, Kutorga, which Mr. WALCOTT is disposed to regard as congeneric with *Schizambon typicalis*, the similarity with typical forms of SIPHONOTRETA, in all external respects save the character of the pedicle-channel, is complete.

Schizambon typicalis.
After WALCOTT.
FIG. 65. Exterior of pedicle-valve.

We have before us an excellent series of specimens representing a species which has been described as SIPHONOTRETA, from dark limestones intercalated between shales at Gloucester, Ontario; beds referred to the age of the Utica slate of New York. The first mention of these fossils was by Mr. J. F. WHITEAVES, in a paper read before the Montreal meeting of the American Association for the Advancement of Science, in 1883; subsequently a more detailed account of their occurrence and association was given by Mr. H. M AMI, in the Ottawa Naturalist for December, 1887. To these gentlemen we are indebted for the opportunity of studying the fossils. Mr. DAVIDSON, who examined the Canadian specimens sent him by Mr. WHITEAVES, identified them with his species *Siphonotreta Scotica*,* but certain differences indicated by Mr. AMI induced the latter to propose therefor the varietal term *Canadensis*.

The general features of these specimens and the numerous fine, smooth spines, indicate a close similarity to DAVIDSON'S species; but in the material received from Mr. AMI are two pedicle-valves, one of which shows the exterior character of the pedicle-passage, and the other somewhat of its internal extension. The former shows this passage to be of precisely the character of that seen in KUTORGA'S *S. fissa* (see Plate IV, figs. 31, 33), and the latter (*idem*, fig. 34) demonstrates that the interior extension of the sipho was carried as far forward as the center of the shell.†

Upon comparison of these specimens with KUTORGA'S description of *S. fissa*, we find an agreement in almost every particular; the shell has the "depressed Terebratula-like form" in distinction from other species of the genus; the striæ of growth, fine and sharp about the apex, become broad and thick toward the margins; the spaces between the rows of spines are smooth or crossed by extremely faint radiating lines; added to this is the character of the pedicle-groove, its floor being crossed by fine, successive growth-lines. Only in the relative number of the surface spines does there appear any difference. In the Russian species these are described as a mass of smooth, hair-like

* Silurian Supplement, p. 218. 1883.

† Mr. DAVIDSON described his Scottish species as having an "acuminated beak, perforated at its extremity by a small circular foraminal aperture" (Geol. Mag., 1877, p. 13). It is therefore evident that the Canadian species is widely different from *S. Scotica*.

spines, with somewhat thicker ones scattered among them; in the American specimens the spines, also smooth, are all of about the same size on any given growth-line, increasing somewhat in length from apex to margin. While this difference in the character of the ornamentation of the surface is apparently so considerable we should hesitate to regard the Russian and American forms as identical. At all events a change of name for the American species is required, and it is proposed to designate it *Schizambon? Canadensis*, Ami.

In allocating these Canadian forms and KUTORGA'S *S. fissa*, tentatively with the genus SCHIZAMBON, it is important not to lose sight of certain apparent differences in the structure of the pedicle-passage. In all the specimens of *Schizambon typicalis* which we have examined, this passage appears to be a simple oval *slit*, transecting the shell almost vertically, without forming the short internal tube evident in the Canadian examples. The same character is shown in Mr. WALCOTT'S figures. The shells of *S. typicalis* are, however, tenuous and this divergence may prove to be entirely fortuitous and due to the imperfect retention of the original characters. It is with this reservation in mind that the Canadian specimens are referred to SCHIZAMBON.

The formation of the foraminal groove in all these species is undoubtedly to be regarded as the progressive track of the pedicle-aperture, indicating its successive positions in different stages of growth.

The agreement in the external character of the pedicle-passage in SCHIZAMBON and SCHIZOTRETA (*Orbiculoidea conica*, Dwight, *O. Forbesi*, Davidson), is very striking; indeed specimens of the pedicle-valve of Professor DWIGHT'S species, in which the apex of the shell is distinctly turned toward the anterior margin, have a resemblance to the corresponding valve in *Schizambon? fissus*. The interior extension of the passage in the two genera is different; in the latter (SCHIZAMBON), a tube ending abruptly in about the center of the shell; in the former the passage is not tubular, except where transecting the shell, or when enveloped by internal callosities. (See the discussion of these characters under genus ORBICULOIDEA.)

With regard to the internal markings of these fossils, it is difficult to detect features susceptible of a satisfactory interpretation. Specimens of the type-

species have been kindly placed at our disposal by Mr. Walcott, and the representations of the interior of both valves given upon Plate IV show the muscular impressions as clearly as we have been able to make them out, and are in essential agreement with Mr. Walcott's conception of them. The interior of the pedicle-valve shows a broad, low sinus with its slightly elevated margins diverging outward from the foramen. Two lateral diverging ridges also take their origin near the beak, while the track of the pedicle-aperture is marked on this surface by a low axial incision. In the opposite valve is a low median ridge with two or more pairs of diverging lateral ridges, the outer of which is the stronger. The extremities of the intermediate ridges frequently show a subcircular discoloration, which may indicate the last implantation of the lateral muscular bands. The whole muscular area appears somewhat thickened and elevated. In *S.? Canadensis*, we have found only evidence of a strong median septum.

Schizambon typicalis appears to be the earliest representative of this group, being from the lower part of the "Pogonip group" of Mr. Walcott, or the lowest Silurian (Primordial?) of the Eureka District, Nevada. It is therefore the predecessor of the other members of the genus, which are from the later faunas of the Lower Silurian: a fact which may account for the divergence of the latter, in some respects, from the type-species.

Genus KEYSERLINGIA, Pander. 1861.

PLATE IV, FIGS. 1-3.

1861. *Keyserlingia*, Pander. Bull. de l'Acad. Imp. des Sciences de St. Pètersbourg, vol. iii, p. 46, pl. ii, fig. 1 *a-h*; in Helmersen's "Die geolog. Beschaffenh. d. unt. Narovataals," etc.

Diagnosis. "Shell inequivalve, subcircular or oval. Ventral valve more or less conical, with a prominent apex which is sometimes near, sometimes distant from the cardinal margin. From this apex diverge posteriorly two low ridges enclosing a flattened triangular area, which is divided in the center by a vertical fissure. The lines of growth cross the hinge-line, forming in the center a faintly depressed triangular groove, as in Helmersenia and Obolus. In the interior of the valve a closed tube is continued from the external fissure, in the

axial line. The first one-third of this tube is swollen and thickened, but thenceforward it passes, with parallel edges, to the anterior margins, where it is probably closed, though usually broken. Dorsal valve more depressed, its greatest convexity being in the center. Cardinal area as in the opposite valve, but narrower. A closed tube, beginning in a swelling just in front of the cardinal line, is continued [from the center of the shell] to the anterior margin as an open channel. Muscular scars as in OBOLUS and HELMERSENIA, but more sharply defined." (PANDER, *loc. cit.*)

Type, *Orbicula Buchi*, Verneuil. 1845. Géol. de la Russ. de l'Europe et des mont. d'Oural, p. 288, pl. xix, figs. 1 *a*, *b*, *c*.

This most peculiar genus presents a close alliance in its muscular impressions to OBOLUS, perhaps more nearly to the NEOBOLUS of WAAGEN, but in its interior closed tubes, that of the pedicle-valve communicating with the external fissure, its relationship to the Siphonotretids is demonstrated. Too little is known of the permanent characters of the fossil to form any reliable conclusions in regard to its proper association, but from the foregoing description it would appear to present the anomalous character of a Siphonotretid in which the pedicle-tube is in a condition of atrophy, compelling the pedicle to pass between the valves, over the cardinal area, as in OBOLUS. The presence of a cæcal tube in each valve, if ever devoted to the passage of the pedicle, is altogether unprecedented.

In regard to the propriety of the generic term KEYSERLINGIA, it may be observed that although PANDER's description and illustration are given without specification of the typical species, the genus was founded on the "ORBICULA, Murch., Vern,, Keys. Géol. de la Russie, 1845, vol. ii, pag. 288," *i. e.*, *Orbicula Buchi*, not *O. reversa*, Vern., which has been quoted by DALL* as the type-species, but which is described on page 289 of that work. The genus ORBICELLA, D'Orbigny, 1847, was evidently founded to include the class of shells for which SHARPE, in the same year, proposed the name TREMATIS. It does not appear, however, that any example was cited with the first use of this term in the

*Bulletin No. 8, U. S. National Museum, p. 39. 1877.

Comptes rendus,* but in 1849,† in giving a list of species referable to the genus, the first mentioned is *Orbicula Buchi*, Verneuil, and it seems that this must be taken as the type of the genus ORBICELLA. Under the rigid enforcement of the current rules for the recognition of priority of nomenclature, KEYSERLINGIA becomes a synonym for ORBICELLA, D'Orbigny, although this construction of the matter does no justice to the intentions of the authors of either generic term.

GENUS HELMERSENIA, PANDER. 1861.

PLATE IV, FIGS. 4-5.

1861. *Helmersenia*, PANDER. Bull. de l'Acad. Imp. des Sciences de St. Pétersbourg, vol. iii, p. 47, pl. ii, fig. 2, *a–g*.

DIAGNOSIS. Shell having the general form of OBOLUS, with a prominent cardinal area depressed in the center by a broad, low pedicle-groove (?). Apex of the ventral valve truncated by a circular hole, which is not produced into an internal tube. Muscular impressions indistinct. No specific name has been proposed for the typical form.

Like the foregoing, this genus shows, in its cæcal (?) apical tube and oboloid cardinal area, characters allying it to both SIPHONOTRETA and OBOLUS, and, like KEYSERLINGIA, also needs a verification of its peculiar features before its proper relationship can be demonstrated.

* Vol. xxv, p. 269.

† Prodrome de Paléont. Stratigraphique, p. 20

Genera DISCINA, Lamarck, 1819; ORBICULA, Sowerby, 1822; ORBICULOIDEA, D'Orbigny, 1847; SCHIZOTRETA, Kutorga, 1848; ORBICULOIDEA, Davidson, 1856; DISCINISCA, Dall, 1871; LINDSTRŒMELLA, sub-gen. nov.; ŒHLERTELLA, sub-gen. nov.; RŒMERELLA, sub-gen. nov.; DISCINA, of authors generally.

PLATE IV E, FIGS. 1-31; PLATE IV F, FIGS. 1-32; PLATE IV K, FIGS. 4, 23, 24.

1842. *Orbicula*, Vanuxem. Geology of New York; Report Third District.
1843. *Orbicula*, Hall. Geology of New York; Report Fourth District.
1847. *Orbicula*, Hall. Palæontology of New York, vol. i.
1852. *Orbicula*, Hall. Palæontology of New York, vol. ii.
1858. *Discina*, Shumard. Trans. St. Louis Academy of Science.
1859. *Discina*, Meek and Hayden. Proceedings Philadelphia Academy Natural Science.
1859. *Discina*, Hall. Palæontology of New York, vol. iii.
1860. *Discina*, Shumard. Trans. St. Louis Academy of Science.
1860. *Discina*, Hall. Thirteenth Rept. N. Y. State Cab. Nat. History.
1860. *Discina*, Hall. Canadian Naturalist and Geologist.
1861. *Discina*, Shumard. American Journal of Science.
1862. *Discina*, Billings. Palæozoic Fossils, vol. i.
1862. *Discina*, Hall. Fifteenth Rept. N. Y. State Cab. Nat. History.
1862. *Discina*, White. Proceedings Boston Society Natural History.
1863. *Discina*, Hall. Sixteenth Rept. N. Y. State Cab. Nat. History.
1865. *Discina*, A. Winchell. Proceedings Philadelphia Academy Natural Science.
1865. *Discina*, McChesney. Trans. Chicago Academy Sciences.
1867. *Discina*, Hall. Palæontology of New York, vol. iv.
1868. *Discina*, Hartt. Dawson's Acadian Geology.
1870. *Discina*, A. Winchell. Proceedings American Philosophical Society, vol. xii.
1872. *Discina* (*Orbiculoidea?*), Hall and Whitfield. Twenty-fourth Rept. N. Y. State Mus. Nat. Hist.
1872. *Orbiculoidea*, Meek. Rept. Palæontology Eastern Nebraska.
1873. *Discina*, Meek and Worthen. Geological Survey of Illinois, vol. v.
1873. *Orbiculoidea*, Hall. Twenty-third Rept. N. Y. State Cab. Nat. History.
1874. *Discina*, Rathbun. Bulletin Buffalo Society Natural History.
1874. *Discina*, Derby. Bulletin Cornell University, vol. i, No. 2.
1875. *Discina* (*Orbiculoidea?*), Hall and Whitfield. Twenty-seventh Rept. N. Y. State Mus. Nat. History.
1875. *Discina* (*Orbiculoidea*), Meek. Geological Survey of Ohio; Palæontology, vol. ii.
1875. *Discina*, Nicholson. Rept. Palæontology Province Ontario.
1878. *Discina*, Ulrich. Journal Cincinnati Society Natural History.
1878. *Discina*, Barrett. Ann. New York Academy of Sciences.
1878. *Discina*, Rathbun. Proceedings Boston Society Natural History.
1878. *Discina*, Rathbun. Bulletin Buffalo Society Natural History.
1878. *Discina*, Dawson. Acadian Geology, Third Edition.
1880. *Discina*, Whitfield. Annual Report Geological Survey of Wisconsin.
1882. *Discina*, Whitfield. Descriptions of New Species of Fossils from Ohio.
1882. *Discina*, Whitfield. Geology Wisconsin, vol. iv, pt. 3, Palæontology.
1882. *Discina*, Ringueberg. American Naturalist, September.

1884. *Discina*, WORTHEN. Bulletin No. 2, Illinois State Museum Natural History.
1884. *Discina*, WHITE. Thirteenth Ann. Rept. State Geologist Indiana.
1884. *Discina*, WALCOTT. Palæontology Eureka District.
1885. *Discina*, CLARKE. Bull. No. 16, U. S. Geological Survey.
1888. *Orbiculoidea*, HERRICK. Bull. Denison University, vol. iv.

From the lack of proper apprehension of the type-species of the genera DISCINA, ORBICULA and ORBICULOIDEA, there has long been, and still exists great confusion among authors in the application of these terms. The zealous endeavors of Mr. W. H. DALL* to unravel the complications in which these genera are involved, and to clear away the uncertainty in regard to the specific values of the types, ought to go far toward removing the general reluctance to disturb the currency of some of these terms, especially DISCINA, a name in almost universal use for forms confessedly not congeneric. The rectifications required in such a case as this are of so fundamental a nature as to cause a certain disquietude, but such instances serve to emphasize the necessity for the enforcement of the rule too often violated, that the application of a generic name must be in harmony with the characters of the type-species.

The genus DISCINA was described by LAMARCK in 1819,† and the typical example taken, *D. ostræoides*, Lamarck, of which neither figure nor description was given. It appears from observations by REEVE,‡ that the original specimen used by LAMARCK was obtained from Mr. J. DE C. SOWERBY, and DALL observes§ that it "is the same species and from the same lot of specimens, as the shell described by Mr. G. B. SOWERBY in the Linnean Transactions, and well figured by him there under the name of *Orbicula Norvegica.* His very excellent figure enables me to speak with positiveness in saying that it is identical with *Crania radiosa*, Gould, of which the type-specimens are before me. The figures of SCHUMACHER are sufficiently exact to allow of identifying the species with his [SCHUMACHER'S] *Crania striata.*" But this *Orbicula Norvegica* of SOWERBY‖ is

*Bull. Museum Comparative Zoology, Harvard College, vol. iii, No. 1. 1871.

† Histoire Naturelle des Animaux sans vertèbres, vol. vi, p. 236.

‡ Conchologia Iconica; Mongr. genus ORBICULA. 1862. See, also, Revision of the History, Synonymy, and Geographical Distribution of the recent Craniæ and Orbiculæ, in Ann. Nat. Hist., vol. x. 1862.

§ Bull. Museum Comparative Zoology, *loc. cit.*, p. 40.

‖ Trans. Linnean Society, vol. xiii, p. 468. 1822.

not the *Orbicula Norvegica* of LAMARCK,* the Lamarckian species having proven identical with the *Patella anomala* of MÜLLER.† This latter species, however, is a CRANIA: and as the *O. Norvegica*, Lamarck, was taken as the type-species of CUVIER'S genus ORBICULA, the genus ORBICULA, in its Cuvierian sense, becomes a synonym for CRANIA. This fact of synonymy was pointed out by Dr. J. E. GRAY, as long ago as 1825,‡ but the genus ORBICULA had become so thoroughly confounded by authors with DISCINA that, to avoid a disturbance of nomenclature, the name was retained by Mr. DAVIDSON§ and Professor HALL,‖ as late as 1852, for the DISCINA of authors, not of LAMARCK.

In 1854. Mr. DAVIDSON¶ considered the *Discina ostræoides*, Lamarck, as identical with *D. lamellosa*, Broderip, 1833,** and therefore, in the absence of a description of *D. ostræoides*, assumed the latter as the type-species. This assumption must now be regarded as inadmissible, and was abandoned by Mr. DAVIDSON in his "General Summary" (1884) and "Monograph of Recent Brachiopoda" (1888).†† In accordance with DALL'S observations, we are compelled to accept *Discina striata*, Schumacher (*Crania striata*, Schumacher, Essai d'un nouveau système des habitudes des Vers Testacés, p. 102, pl. xx, figs. 1 a–f, 1817, = *Orbicula Norvegica*, Sowerby, 1822, not Lamarck, 1801, = *Discina ostræoides*, Lamarck, 1819), as the typical species of the genus. This species is not to be confounded with the *Discina striata*, Sowerby,‡‡ which is a Silurian (Ludlow) form, while SCHUMACHER'S species, the designation of which antedates that of SOWERBY, is recent and of West African habitat.

The diagnosis of the genus DISCINA, as derived from the species *D. striata*, Schumacher, is given by DALL in the following terms:

"Sub-genus DISCINA (LAM.), DALL. Shell of rather solid texture, with a con-

* Syst. Nat., p. 140. 1801: and Hist. Animaux sans vertèb., Ed. I, vol. vi, p. 242. 1819; Ed. II, vol. vii, p. 316. 1836.

† Zoologiæ Danicæ Prodromus, p. 237. 1776.

‡ Annals of Philosophy, New Series, vol. x, p. 244.

§ Tertiary Brachiopoda.

‖ Palæontology N. Y., vol. ii.

¶ Introd. Brit. Foss. Brach.

** Proc. Zool. Soc., vol. i, pp. 124, 125.

†† Trans. Linnean Society, Second Series, Zoology, vol. iv, pt. 3.

‡‡ Sil. Syst., pl. x, fig. 21. 1839, and DAVIDSON, Silur. Brach., p. 67, pl. vi, figs. 1–4.

siderable amount of calcareous matter in it: no signs of punctation to be seen with a half-inch objective. Valves convex, the lower valve varying in amount of convexity with its habitat, but always more or less inflated. A small, sharp, longitudinal septum rises from the center of the lower valve, of a subtriangular shape, covering and hiding a small tubular perforation of the apex of the shell. This perforation is very oblique, and from its internal opening a groove extends backward nearly half-way to the posterior border of the shell inside. The anterior muscular scars meet in front of the septum and form a semilunar elevation with the points directed backward. The posterior scars in the lower valve are small and widely separated. On the external surface the foramen appears nearly in the middle of the shell and the furrow is continued *anteriorly* for a short distance. (There is no furrow in my specimens outside *behind* the foramen, which is the only point of difference from SOWERBY's figure.) Upper valve convex, apex subcentral: a slight median longitudinal callus internally. There is no strongly impressed disc about the foramen as in DISCINISCA, though slight traces of a differentiated area exist there."*

Discina striata, Schumacher, is the only known representative of this genus. (See Plate IV K, figs. 23, 24.) Its minute, almost imperceptible foramen (so small that both SCHUMACHER and GOULD, not seeing it, referred the species to CRANIA), and the arrangement of its internal impressions, separate it by a full generic difference from its nearest allies. With DISCINA, therefore, we have at present nothing to do among the palæozoic brachiopods.

The foregoing limitation of the genus DISCINA by Mr. DALL left all the other recent species, currently referred to that group, without a designation, and for these the author proposed the term DISCINISCA, with the following definition:†

"Sub-genus DISCINISCA, Dall, = DISCINA, Auct. Lower valve more or less flattened, concave or compressed, Upper valve more convex; apices of both subcentral or subposterior. Lower valve with a small septum as in DISCINA, behind which is an impressed disc or area, externally concave and internally elevated. This is perforated by a longitudinal fissure, extending from a short distance behind the septum nearly to the posterior margin, which is often slightly indented behind it. Shell more or less horny in texture, minutely tubulose. Type, *Discina lamellosa*, Broderip."‡

* Bull. Mus. Comp. Zool., vol. viii. No. 1, p. 39.

† Bull. Mus. Comp. Zool., vol. iii. No. 1, p. 37.

‡ Proc. Zool. Soc., 1833, p. 124.

The character of most emphatic importance in this group is the broad, elevated, internal pedicle-disc with thickened lateral margins, but with a thin, tenuous central area, perforated by an oval slit passing *directly*, not obliquely, through the substance of the area. On the outer surface of the shell this disc is much depressed, interrupting for its entire width the concentric growth-lines, and showing upon its surface only the progressive track of the foramen as it has become closed in its advance from the apex toward the posterior margin with the growth of the shell.

When we turn to the consideration of the generic value of palæozoic fossils, passing current under the name DISCINA, we are met by two serious obstacles: (1) it is rarely that these fossils are preserved so as to show the exact character of the foraminal aperture and area, this condition, no doubt, being largely due to the extreme, often membranous tenuity of the parts immediately surrounding the aperture, and the ease with which the projecting portions of the area are broken; (2) the illustrations of these fossils which have been given by authors are, as a rule, drawn on so small a scale, or from such unsatisfactory specimens that it is impossible to form an accurate idea of the character of the aperture and disc. Notable exceptions to this general statement will presently be cited.

ZITTEL,* recognizing the three divisions, DISCINA, ORBICULOIDEA and DISCINISCA, as sub-genera of DISCINA, Lamarck (*i. e.* (?), the current interpretation of DISCINA, Lamarck), is authority for the statement that the genus DISCINISCA ranges from the Silurian faunas to the recent. Personally, we have no knowledge of any palæozoic species showing the elevated disc and vertical slit characterizing DISCINISCA, and are not aware that any author has described and figured a palæozoic species which can be safely referred to this genus.

We have before us a very large amount of material representing the palæozoic "Discinas," which has been carefully selected for the purpose of studying the variations in the characters of the pedicle-groove and disc. Among the species well represented are *Orbiculoidea conica*, Dwight, from the Trenton, *D. tenuilamel-*

* Handbuch der Paläontologie, vol. i, p. 667. 1880.

lata, Hall (=*Orbiculoidea Forbesi*, Nicholson (not Davidson)=*D. clara*, Spencer,= *D. solitaria*, Ringueberg), from the Niagara, *D. Conradi*, Hall, and *D. discus*, Hall, from the Lower Helderberg, *D. ampla*, Hall, from the Oriskany sandstone, *D. minuta*, Hall, from the Marcellus shales, *D. media*, Hall, *D. grandis*, Vanuxem, *D. humilis*, Hall, *D. Randalli*, Hall, *D. Doria*, Hall, *D. marginalis*, Whitfield, from the Hamilton group, *D. Lodensis*, Vanuxem, from the Genesee shales, *D. pleurites*, Meek, from the Waverly, *D. Newberryi*, Hall, from the Cuyahoga shales, *D. nitida*, Phillips, *D. Manhattanensis*, Meek and Hayden, from the Coal Measures, and many additional species, with several unidentified, probably undescribed forms from various horizons.

The pedicle-perforation in these fossils is not, as usually represented, a simple, elongate fissure, extending from beneath the apex, one-third, one-half or the entire distance to the posterior margin. On the contrary, just behind the apex, and removed from it by a distance varying with the stage of growth of the animal, is the external opening of a perforation, which passes very obliquely backward through the substance of the shell and opens on the interior surface not far from, but within the margin of the shell, having thus precisely the re-

FIG. 63. Vertical section of the pedicle-valve of *Discina striata*. After DAVIDSON.

FIG. 64. Vertical section of the pedicle-valve of *Orbiculoidea*

verse position to that of *Discina striata* as given by DAVIDSON,* whose figure is here copied, but very much greater obliquity.

On the *external surface* of the pedicle-valve, the *pedicle-groove*, which begins at the apex, intersects more or less abruptly the usual concentric ornamentation of the shell, but it is very narrow, and its surface generally smooth or with faint indications of growth-lines. In all instances this furrow begins at the apex; its length, however, in any given species, will, as just noticed, depend on the stage of growth, for the pedicle-aperture evidently keeps the same relative distance from the apex in all periods of development. This portion of the

* Trans. Linnean Soc., vol. iv. pt. 1, pl. 25, fig. 26. 1888.

pedicle-groove may then be regarded as the track left by the advance of the external opening of the foramen, closed by later testaceous secretions and quite homologous to the anterior portion of the great depression surrounding the pedicle-slit in DISCINISCA. In certain thick-shelled species, like *Orbiculoidea conica* and *O. Forbesi* (to which reference will again be made under the discussion of the genus SCHIZOTRETA, Kutorga), the evidence of the external furrow ends abruptly with the disappearance of the pedicle-groove into the substance of the valve. In general, however, the shell of palæozoic "Discinas" is very tenuous, and their compression in the process of fossilization often confounds the features of the inner and outer surfaces of the pedicle-area, making them appear continuous. It seems evident that in these fossils the groove upon the external surface is, as a rule, of essentially the same character as that seen in DAVIDSON'S figures of *Orbiculoidea Forbesi*,* DWIGHT'S figures of *O. conica*,† and those of the latter species given on Plate IV F of this volume; outside the foramen the concentric lines following without interruption, as on any other portion of the external surface.

On the *internal surface* of the pedicle-valve the track of the pedicle-groove extends along nearly the entire radius of the shell. In no species have we found the internal character of this feature so well retained, and showing so clearly the changes passed through from youth to maturity as in an undescribed species,‡ from the Cuyahoga shales at Berea, Ohio, and in *D. nitida* from the shales of the lower Coal Measures, at Springfield, Illinois. The specimens from these formations frequently preserve the test without mutilation or much distortion. Early in the life of these species the foramen has penetrated the internal surface near the apex, and whatever groove has been made upon the outer surface by the radial progress of the foraminal aperture is also marked on the inner side, and is usually somewhat calloused, conspicuously so in adult

* Silurian Brachiopoda, pl. xii, figs. 14, 14 b, 15, 18.

† American Journal of Science, 1880, pl. xxi, figs. 1–5.

‡ This species has come to us from various quarters labelled "*Discina Newberryi*, Hall." With the latter however it does not agree, the pedicle-area not being elevated nor so broad as in that species, and the brachial valve rather more convex with its apex nearer the center. The original specimens of *D. Newberryi* are from a ferruginous sandstone, 110 feet below the conglomerate at Cuyahoga Falls; those of the species in question, which may be termed *Orbiculoidea Herzeri*, from greenish-black shales at Berea, Ohio.

specimens. The passage for the pedicle is so oblique to the planes of the surfaces of the valve that its inner termination is not abrupt but commonly produced into a fine groove, visible over nearly or fully the distal half the length of the pedicle-area and sometimes traceable even to the margin of the shell. Contemporaneous with the growth of the shell is the development of a callosity close about the margins of this groove, which often becomes so high as not only to have deepened the passage, but in advanced age to have wholly enveloped it, the two callosities becoming coalesced and leaving an opening for the pedicle only at their posterior extremity. (See Plate IV F, figs. 8–17.) This callosity is developed with substantial symmetry in *D. Herzeri* (see foot-note on preceding page), *D. marginalis*, *D. ampla*, etc., occasionally showing a tendency to irregular, though not unsymmetrical growth. In many species it never attains a great development, being scarcely more than a linear elevation or a narrow ridge, bordering and partially or wholly enveloping the pedicle-groove; the adult condition in such species being essentially identical in this respect to the earlier stages of growth in those where the callosity eventually closes all but the aperture of the foramen. In *Orbiculoidea tenuilamellata*, we find the internal character of the pedicle-area of precisely the same nature. On the inside no indication is given of the length of the external groove, but the inner callosity extends from the apex almost, if not, in some instances, quite to the posterior margin, without leaving any trace upon the external surface, when the shell is uncompressed.

So far as we are aware the features described above have been rarely illustrated by any author. BARRANDE has given* illustrations of the exterior and interior of his species, *D. Bohemica*, the former showing the short external groove, and the latter the inner prolongation of the groove or ridge to the margin. The same features may be seen in his figures of *D. Mæotis*.† Attention may also be directed to Mr. DAVIDSON's figure of *D. nitida*,‡ which shows very distinctly from the interior the floor of the long pedicle-groove and the inner opening of the foramen; and to Mr. MEEK's figure of *Orbiculoidea*, sp. ?, in

* Système Silurien du Centre de la Bohême, vol. v, pl. 97, fig. v, 1 A, 2 a.

† Système Silurien du Centre de la Bohême, vol. v, pl. 100, fig. ii.

‡ Permian and Carboniferous Supplement, pl. xxx, fig. 13 a.

the Final Report of the United States Geological Survey of Nebraska, and reproduced upon Plate IV F, fig. 31.

It is now easy to find an explanation of the apparently great variation in the length of the groove in these fossils. Even in a given species it will appear sometimes short, at other times seeming to reach nearly or quite to the margin, according as the specimen shows the outer or the inner surface. Unquestionably the length of the external groove is a matter of specific variation to a slight extent only, its development keeping pace with the age of the shell, while the length of the internal furrow appears to be, to a much more considerable degree, susceptible of variation in a given species.

Leaving the further discussion of the characters of these fossils for subsequent reference, we may turn to the consideration of the generic term:

ORBICULOIDEA, D'Orbigny, 1847. Considerations zoölogiques et géologiques sur les Brachiopodes; Comptes rendus, vol. xxv, p. 269.

The definition of this term was first given in the Prodrome de paléontologie stratigraphique, 1849, and is in the following terms: "Coquille de contèxture cornée non perforée, dont la valve inférieure concave est pourvue d'un ouverture laterale ou crochet pour le passage d'un pedicule simple," the first example cited under this definition being the *Orbicula Morrisi*, Davidson. Mr. DALL has observed* that in neither the first use of the term,† nor in the second,‡ was an example cited, and, therefore, reaches the unavoidable conclusion that *O. Morrisi*, being the first citation made by the author, must be assumed as the typical species. Mr. DAVIDSON, in 1853,§ was disposed to consider KUTROGA'S genus, SCHIZOTRETA, as synonymous with ORBICULOIDEA, and took KUTORGA'S type, *S. elliptica*, as the type of the latter genus. Subsequently (1866),‖ holding to the equivalence of these terms, he did not modify his opinion as to the type-species of ORBICULOIDEA.

* Bulletin No. 8, U. S. National Museum, p. 51. 1877.

† Comptes rendus, vol. xxv, p. 269.

‡ Ann. Sci. Nat., vol. xxx, p. 351. 1850.

§ Introd. British Fossil Brachiopoda, pp. 129 131.

‖ Silurian Brachiopoda, pp. 72, 73.

The *Orbicula Morrisi* was described by DAVIDSON* in 1848 from imperforate valves only, and his subsequent notice† of the species (1866) as (?) *Discina Morrisi*, did not add essentially to the knowledge of its characters. In 1855, however, McCOY had noticed‡ the species as *Discina Morrisi*, and, without giving any figures, described the pedicle-valve, from which it would appear that it is depressed-convex, concave about the margins, the "fissure" being "very broad, oval, half its length from the posterior margin." We are not able to gather from these meager details, or from any other published description of the species, the precise character of the foraminal aperture, and having been unable to obtain suitably preserved specimens of the pedicle-valve, can not directly compare this feature with that of the forms under discussion above. However, the imperforate valve in the species is strongly convex, with an excentric, posteriorly directed apex, and this fact combined with McCOY's description of the pedicle-valve, gives to the species a general contour in precise harmony with that prevailing among the palæozoic "Discinas" generally, while those species now passing under the name of ORBICULOIDEA, Davidson, are distinctive in having the relative convexity of the valves reversed, the pedicle-valve being the more convex.

This relative convexity of the valves in "Discina," though always liable to diminution from compression in fossilization, is a permanent feature, and, as far as our observations extend, invariably associated with the foraminal characters already described, except in the instances cited below. We therefore feel justified in regarding all these species as congeneric (with reservations in favor of forms of the type of *Orbiculoidea conica*, *O. Forbesi*, etc.), and adopting for them the term, ORBICULOIDEA, D'Orbigny, not Davidson, = DISCINA (palæozoic species), of authors.

DIAGNOSIS. Shells subcircular or subelliptical in outline, inequivalve. Apices excentric. Pedicle-valve depressed-convex or flattened, with the apex slightly elevated and inclined posteriorly. On the exterior of the valve a narrow pedi-

* Bull. Soc. Géol. de France, Second Series, vol. v, p. 334. 1848.

† Silurian Brachiopoda, p. 65, pl. vii, figs. 10-12. 1866.

‡ British Palæozoic Fossils, p. 190.

cle-furrow, abruptly intercepting the ornamentation but not penetrating the substance of the shell, begins just below and behind the apex, extends over a greater or less portion of the radius of the valve, and, at its distal end, is produced into a short tubular sipho, which traverses the substance of the shell obliquely backward, emerging on the interior surface, where it produces a narrow groove, and usually terminates before reaching the margin of the valve. On the interior, the position of the external groove is marked by a thickened ridge extending from the apex, and this is continuous with the thickened margins of the internal groove, which, in advanced age, may become so developed as to envelop this groove, except at its outer end.

The larger or brachial valve is depressed-conical, with the apex more strongly directed backward than in the opposite valve. The interior shows a fine longitudinal ridge or septum extending from the apex forward. Otherwise the internal markings are not satisfactorily known.

Shell-substance composed of alternating lamellæ of corneous and mineral matter, the latter often removed in fossilization, making the shell appear essentially phosphatic. Surface ornamentation usually consisting of fine, crowded or distant, sometimes lamellose concentric lines, occasionally crossed by radiating lines or ridges.

Type, *Orbicula Morrisi*, Davidson. Wenlock limestone.

Under the above limitations these fossils appear to constitute a very compact generic group subject to no essential variation. In order to properly interpret their pedicle-characters as usually preserved, emphasis must again be laid upon the fact, that, by compression of the tenuous shell, the external and internal features of the groove are frequently made to appear as continuous, and the careful observer will seek examples in which the normal contour of the shell has not been disturbed in fossilization. In some species the external depression of the pedicle-area is very considerable (*D. Newberryi*, *D. Conradi*, *D. ampla*), though not of the extent seen in DISCINISCA, nor so greatly thickened; and such species often show more distinctly the composition of the base or floor of the groove lying between the apex and the external aperture, a tripartite

arrangement in which the middle portion represents the path of the aperture. This character is not only common to palæozoic "Discinas" generally, but is seen in SCHIZOTRETA, DISCINISCA and SCHIZOCRANIA. A serious difficulty may sometimes arise in the determination of the character of the pedicle-groove outside or behind the aperture. By examining a specimen of the recent *Discinisca lamellosa*, it will be seen that the callous margins of the groove in this part of the shell are connected by only a thin transparent lamella, which, if broken, as is often the case, would leave the valve with a slit extending to the margin, as in SCHIZOCRANIA or TREMATIS. In the fossils under discussion, there sometimes appears evidence that the sides of the groove are thus separated and not infrequently the pedicle-valve has been so figured, with a slit extending quite to the margin.

In certain species we have evidence that in the earlier stages of growth the pedicle-groove opens upon the margin, its distal edges gradually approaching as growth advances, until, at maturity, they are united, and with further increase in age, the distance of the groove from the margin is augmented. No adult example, however, presents any other condition of this part of the shell than that above described, except when a matter of imperfect preservation. We have axamined a fragment of bituminous slate, from the lower Coal Measures at Springfield, Illinois, bearing a great number of individuals of the *Discina nitida* of Phillips (as identified by the Illinois palæontologists), in various stages of growth, from a diameter of .9 mm. to that of 9 mm., the latter being the size of the average adult. A pedicle-valve .9 mm in diameter, shows that the margins of the groove, from the beginning of the foramen outward, are quite widely separated, but at a size of 5 mm. they have come into close approximation, without uniting, while an individual of 5.5 mm. diameter has them distinctly united, but in another, measuring 6.5 mm. diameter, they are still free. Larger examples, in which the groove is wholly enclosed, bear a linear incision or track of the groove quite to the margin. The same developmental process appears in *Discina minuta*, Hall, of the Marcellus shales, and *D. Herzeri*, of the Cuyahoga shales, the younger stages of growth showing that the pedicle-groove is open at the margin.

We must therefore consider the enclosure of the groove an essentially adult character of ORBICULOIDEA, and in cases like that of the genus TREMATIS, where the substantial difference from ORBICULOIDEA lies in the persistent open pedicle-fissure, we may regard the generic distinction as founded not on a genetic, but rather on a developmental difference, TREMATIS retaining at maturity a pedicle-passage having a character, which in ORBICULOIDEA, is embryonic ; and as far as these characters alone are concerned, the same is essentially true of SCHIZOCRANIA. There are species passing under the name of DISCINA, which show such features as these at maturity; as for example, a form in the Lower Helderberg commonly referred to the *Discina discus*, Hall, of which the best specimens obtainable indicate that the aperture is similar to, but considerably more contracted than in SCHIZOCRANIA, approaching TREMATIS in this respect; but the character of the upper valve, its marginal beak and finely radiated surface, show further agreement with SCHIZOCRANIA, and it seems best to remove the species, provisionally at least, to this genus.*

Again, the *Discina pleurites* of MEEK, from the Waverly sandstones of Ohio, is a species whose form and contour is precisely that of SCHIZOCRANIA ; the upper valve is evenly convex, and has a submarginal beak, but its surface markings consist wholly of concentric striæ. As in SCHIZOCRANIA, also, attachment is largely effected by the margin of the upper valve, while the pedicle-passage is an open fissure extending from the termination of the floor of the groove to the margin, where it is somewhat constricted, as in TREMATIS: at the same time the floor of the pedicle-groove partakes of the tripartite structure seen in all these genera. The entire pedicle-area is conspicuously elevated, as in *Orbiculoidea Newberryi*, and it may be quite proper to regard these two species as forms in which the development of this feature has been arrested at an earlier stage in one (*D. pleurites*) than in the other. With our present comprehension of the genera SCHIZOCRANIA and TREMATIS, it is impossible to admit this species to either, for no specimen has shown a trace of muscular imprints, which are usually very strong in the upper valves of both these groups.

* See in Supplement description of *Schizocrania? Helderbergia*, sp. nov.

Neither can it be assigned to ORBICULOIDEA without opening that genus to the reception of heterogeneous forms. For convenience, therefore, it is desirable to indicate the close but subordinate relations of this species* to ORBICULOIDEA, by the use of the new term ŒHLERTELLA.

The muscular impressions in ORBICULOIDEA are extremely faint and rarely discernible at all. We have seen no specimens showing them as clearly as the pedicle-valve of *D. nitida*, figured by Mr. DAVIDSON and referred to above, where they are resolvable into anterior and posterior adductors, situated close together near the extremities of the pedicle-area, the posterior pair being at the distal extremities of long progressive scars radiating from near the apex. This arrangement of the scars indicates a general agreement with the muscular anatomy of *Discinisca lamellosa*.

Orbiculoidea Randalli, Hall, a remarkably large species, known only from a single rather imperfect interior of the pedicle-valve, from the Hamilton group of New York, shows a slight median septum passing from the apex forward, comparable to that in *Discinisca lamellosa;* from this radiate a series of furrows, probably of vascular nature, which lie only within the inner lamellæ of the shell, apparently not interrupting the external ornamentation. It will be interesting to learn whether this shell is congeneric with *Orbiculoidea Morrisi*, Davidson.

Occasionally, in the brachial valves of American species, are seen two extremely faint ridges beginning near the apex and approaching each other at their anterior termination, nearly meeting the inconspicuous median septum. (See Plate IV F, fig. 22; also, BARRANDE's figure of *Discina reversa*, Keyserling, Système Silurien, vol. v, pl. 95, fig 1, 2 A.) In a large form from the Hamilton group of New York, usually confounded with *O. grandis*, Vanuxem, these characters reach an extraordinary development and become most prominent features of the interior, beginning just in front of the apex, and, as they con-

* The mode of preservation of this species frequently leads to deception in regard to its pedicle-characters. When the two valves are preserved together, the breaking away of the upper portion of the larger valve often leaves its marginal portion surrounding the lower valve and closing the pedicle-aperture. In many such cases it is extremely difficult to distinguish the parts belonging to the respective valves on account of the thinness of the shell, and we have taken pains to accumulate a very large representation of the species in order to fortify our conclusions. For much of the material at our disposal we are indebted to the favor of Professor C. L. HERRICK, of Cincinnati.

verge, making a very abrupt slope on their outer margins, but a gentle slope inward. The median septum is very faint until it meets the lateral ridges, when it widens over the anterior portion of the shell. Between each ridge and the median septum the surface is marked by radiating muscular lines which indicate the position of the anterior adductors, and at the posterior extremity of each ridge lies a circular impression, undoubtedly of muscular origin, but whose function is not disclosed by comparison with allied forms. Our present knowledge is insufficient to determine the degree of development of these lateral muscular ridges throughout the "Discinas," but in the typical forms upon which we have based the discussion of the foraminal characters they do not appear at all, and we are disposed to regard them at least as of subsidiary generic importance, and propose to place this Hamilton species under the sub-generic term

LINDSTRŒMELLA, sub-gen. nov. (See Plate IV E, figs. 25–28.)

DIAGNOSIS. Shells with outline, contour and pedicle-characters as in ORBICULOIDEA. Brachial valve with a faint median septum and two strong approximating ridges or muscular fulcra, beginning just behind a transverse line passing through the apex and rapidly converging to meet the median septum. Anterior adductor scars lying between these ridges and the median septum; a circular muscular scar at the posterior extremity of each ridge.

In the pedicle-valve, the foramen has essentially the structure of ORBICULOIDEA, but its distal margins, though lying in close juxtaposition appear not to have been united.

Type, *Lindstrœmella aspidium*, sp. nov.*

In the pedicle-valves of "Discinas" are often seen traces of what, at first sight, appear to be similar, though faint ridges, situated, however, further backward, meeting at the apex and diverging along the pedicle-groove. We are satisfied that this feature is produced by the flattening of the shell about the more or less thickened internal pedicle-area and is purely accidental. In several of M. BARRANDE's figures this feature is made to appear in various degrees of

* For description see Supplement.

development as a conspicuous character of the interior; *vide D. reversa?* Pl. 96, fig. I, 3 A, 4 A, 5 A, 6 A; *D. tarda*, Pl. 96, fig. V, 4 A; *D. rugata?*, Pl. 98, fig. I, 6 C; *D. intermedia*, Pl. 99, fig. VI, 1 A, 2 A, 3 A, 4 A (Système Silurien, vol. V, 1879).

The fossils which have been referred to ORBICULOIDEA, Davidson, not D'Orbigny, the best known of which are *O. Forbesi*, Davidson, and *O. conica*, Dwight, differ from all the foregoing in having the perforated valve very convex and the imperforate one depressed-conical (*O. Forbesi*), or flat (*O. conica*).

This convexity of the pedicle-valve attains an amazing development in Professor DWIGHT's remarkable species, the umbo being prolonged into a high cone, with the apex inclined toward the anterior margin of the shell. The same inclination is observable in specimens of *O. tenuilamellata*, from the Niagara group at Hamilton, Ontario, but only to a slight degree.

The pedicle-groove has essentially the character seen in ORBICULOIDEA, D'Orbigny, but is usually much more distinctly retained on account of the greater thickness of the shell, which is in striking contrast to its tenuity in the last named group. A question may fairly arise as to the advisability of considering the differences mentioned in these two groups as of generic importance, but it was upon a strictly congeneric species that KUTORGA established the genus SCHIZOTRETA, a name which has uniformly been regarded as a synonym for DISCINA = ORBICULOIDEA, Davidson, since Professor MORRIS' observations on the subject in the Annals and Magazine of Natural History in 1849.*

To apprehend the proper status of this group, KUTORGA's diagnosis is appended:

SCHIZOTRETA, Kutorga. Ueber die Siphonotretææ: Verhandl. der russ.-kais. mineral. Gesellsch. zu St. Petersburg, pp. 272, 273. 1848.

"The chief character of this genus lies in the peculiar external slit-shaped pedicle-aperture, the position of which is precisely the reverse of that in the preceding genera [SIPHONOTRETA, etc.]. The apex of the beak is greatly elevated, but far from being in the center of the valve, and from it passes over the strongly convex cardinal slope of the cone, toward the posterior margin, a

* Second Series, vol. iv, p. 315.

narrow elliptical slit, which extends scarcely for one-half the face of the cone, thence merging into the inner sipho. The surface of the shell is covered with simple, elevated, concentric lines of growth which are interrupted by the slit. The ventral [=brachial] valve is very depressed-convex or even flat; its beak is sharply defined, depressed, directed toward the cardinal margin, and in no sense marginal, for between it and the margin are several unbroken growth-lines."

Further, under the discussion of the type-species, *S. elliptica*, Kutorga, the author observes (p. 274):

"The study of the slit under the microscope, with an aplanative ocular and enlargement of 45 diameters, convinces me that there is no fissure in the bottom of the slit opening into the interior of the shell. It is very clearly seen that the bottom is covered with the same epidermal layer crossed by fine growth-lines; and, further, that the posterior end of the outer slit merges into the cylindrical sipho."

It is important to have these latter observations in mind, for while they agree minutely with the character of the aperture in ORBICULOIDEA, Davidson, the feature is not so well understood from a study of KUTORGA's figures. It thus appears that there is no essential difference in SCHIZOTRETA, Kutorga, and ORBICULOIDEA, Davidson, and the former term may very well stand to include those forms essentially in agreement with ORBICULOIDEA, D'Orbigny, but having thicker shells and the relative convexity of the valves reversed, bearing, in fine, the same relation to D'ORBIGNY's genus as STROPHONELLA to STROPHODONTA, among the articulate brachiopods.

Professor DWIGHT has shown that the muscular impressions of the brachial or imperforate valve in *Schizotreta conica*, consist of two strong excavated anterior adductors approaching toward the center of the shell, and separated by a prominent septum which is continued from a somewhat thickened posterior muscular area. Better preserved interiors of this species will, no doubt, show other scars and determine more closely its relations in these respects to *Orbiculoidea nitida* and *Discinisca lamellosa.*

Another peculiar phase of reversion in certain features characterizing the typical ORBICULOIDEA, is seen in the species *Discina grandis,* Vanuxem, a not

uncommon form in the sandy shales of the Hamilton group. The upper valve is elevated and obtusely conical, with its apex slightly posterior, while the lower or perforated valve when uncompressed is extremely concave, much more so on the anterior than on the posterior slope, the entire surface of the valve rising for a considerable distance into the cavity of the other valve. Thus the general contour of the pedicle-valve is precisely the reverse of that usual in ORBICULOIDEA, while the structure of the pedicle-aperture appears to be essentially alike in both. This reversion is a sufficient basis for the separation of this species and all others which may be found to agree with it in this respect, from ORBICULOIDEA, and we propose therefor the sub-generic term, RŒMERELLA, sub-gen. nov.

FIG. 65. Diagrammatic figure of *Rœmerella grandis*, showing the concavity of the pedicle-valve.

Type, *Rœmerella grandis*, Vanuxem. (See Plate IV E, figs. 29–31.)

ORBICULOIDEA is not positively known as a member of faunas older than the Silurian. The *Discina Acadica* of HARTT (Dawson's Acadian Geology, Second Edition, p. 644. 1868), from the St. John formation, is not now regarded as a brachiopod. Mr. WALCOTT refers it to the Gasteropod ? genus, PALACMÆA ?, and Mr. MATTHEW to STENOTHECA, *s.g.*, PARMORPHORELLA. *Discina ? inutilis*, Hall, from the primordial sandstones at Mazomanie, Wisconsin, is very imperfectly known. The American palæozoic formations are known to contain about forty described species of ORBICULOIDEA. The genus appears to have developed rapidly in species and have attained a culmination in the Middle Devonian faunas, from which a considerable amount of undescribed material is to be found in collections. In the Menevian of Wales, *Discina pileolus*, Hicks, appears to be a genuine ORBICULOIDEA, and if so, may be considered as the earliest known representative of the genus. The *D. Caerfaiensis*, Hicks, from the Middle Caerfai group of St. Davids, is known only from its upper valve.

GENUS TREMATIS, SHARPE. 1847.

PLATE IV G, FIGS. 1–20.

1825. *Orbicula*, SOWERBY. Zoological Journal, vol. ii.
1842. *Orbicula*, EMMONS. Geological Survey N. Y., Rept. Second District, p. 395.
1847. *Orbicula*, HALL. Palæontology N. Y., vol. i, p. 100, pl. xxx, figs. 11 a–d.
1847. *Trematis*, SHARPE. Quarterly Journal Geological Society, vol. iv, p. 66 (June).
1847. *Orbicella*, D'ORBIGNY. Comptes rendus, vol. xxv. p. 269 (August).
1853. *Trematis*, DAVIDSON. Introduction to British Fossil Brachiopoda, p. 130.
1855. *Trematis*, EMMONS. American Geology, pt. 2, p. 201. fig. 63.
1859. *Trematis*, HALL. Twelfth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 72.
1862. *Trematis*, BILLINGS. Palæozoic Fossils, vol. i, pp. 52, 53.
1866. *Trematis*, HALL. Descr. New Species Crinoidea and other Fossils, etc.
1866. *Discina* (*Trematis*), DAVIDSON. British Silurian Brachiopoda, pp. 69–71.
1871. *Discina* (*Trematis*), DAVIDSON. British Silurian Brachiopoda, p. 344.
1871. *Trematis*, DALL. Bull. Mus. Comp. Zoology, vol. iii, No. 1, p. 37.
1872. *Trematis*, HALL. Twenty-fourth Rept. N. Y. State Mus. Nat. Hist., p. 221, pl. 7, figs. 22–25.
(?) 1874. *Trematis*, MILLER. Cincinnati Quart. Journ. Science, vol. i, p. 347.
1875. *Trematis*, HALL. Twenty-third Rept. N. Y. State Cab. Nat. Hist., p. 243, pl. xiii, figs. 17–19.
1875. *Trematis*, HALL and WHITFIELD. Geol. Surv. Ohio; Palæont., vol. ii, p. 70, pl. i, figs. 4–9.
1875. *Trematis*, NICHOLSON. Palæontology of the Province of Ontario, p. 18.
1878. *Trematis*, MILLER and DYER. Contributions to Palæontology, No. 2, p. 8.
1889. *Trematis*, ULRICH. American Geologist, vol. iv, pp. 22, 23.

DIAGNOSIS. Shell subcircular or transversely oval in outline. Pedicle-valve unevenly convex, more or less depressed over the posterior region; apex at, or behind the center; directly beneath it begins the pedicle-fissure, which transects the shell, vertically widening to the posterior margin with straight or outwardly curving edges. Brachial valve evenly convex, with its apex marginal and slightly projecting. On the interior, the pedicle-valve shows a faint median furrow extending from the angle of the fissure to the apex of the shell; this groove widens at its apical termination and may represent a point of muscular attachment. The sides of the fissure are often thickened by callosities similar to those sometimes seen in species of ORBICULOIDEA. From the apex of the valve extend radiating and branching vascular sinuses.

In the brachial valve the posterior margin is much thickened and broadly grooved to allow the extrusion of the pedicle. This thickening does not take the form of a cardinal area or shelf, but is rather a callosity closely appressed against the interior surface of the shell, the central portion being projected beyond the margin of the pedicle-valve. Directly below and in front of this area are two

transversely elongate scars, adjustors or posterior adductors, which are usually partly concealed by the progressive overgrowth of the cardinal thickening. A faint median septum begins between these scars and passes forward, becoming more prominent over the tongue-shaped median elevation which separates the large central scars. These impressions are oblique and are not simple, each appearing to be composed of two, if not three distinct scars, making a posterior, a median and an anterior pair. What appears to be the posterior pair is small, and sometimes quite sharply defined, the central pair very much larger, and the anterior pair narrow, situated at either side of the angle of the median callosity and separated by its apex. The specialization of the first of these scars is not satisfactorily established; the entire impression is deeply excavated. In some well preserved specimens, there is also evidence of external, marginal scars lying just in front of the outer ends of the posterior adductors.

Surface of both valves more or less completely covered by a beautiful ornamentation consisting of punctures or small pittings of varying depth, arranged either in quincunx (*T. terminalis*) or in radiating rows; in the latter case they may be distant from one another without intervening ridges (*T. umbonata*), or lie in radiating furrows, when they are either circular (*T. millepunctata*) or subrectangular (*T. Ottawensis*).

Shell-substance composed of an outer calcareous layer with a series of inner corneous lamellæ. The outer layer varies in thickness in different species and is coarsely punctated by the pittings constituting the surface ornamentation. The corneous layers are impunctate.

Type, *Trematis terminalis*, Emmons.

Observations. The interior of the brachial valve in this genus presents at first consideration a striking similarity to that of the pedicle-valve in Obolus. In both the arrangement of the muscular scars is essentially into three pairs: (1) the posterior adductors (cardinals in Obolus), (2) the anterior adductors, (3) the externals. The second of these pairs is strongly excavated in both genera and bordered by a median thickening. Herein lies the difference in both these genera from Dinobolus, with which there is a superficial agreement; these

muscular impressions in that genus lying upon the median thickening but in front of it in the others. The presence of a median septum in both OBOLUS and TREMATIS adds to their similarity. The large median scars in TREMATIS, however, are composite, and thus indicate an important difference in the character of the muscular anatomy of the two genera. In position, if not in function, the anterior and median members of the great central scars in TREMATIS correspond with the anterior laterals and centrals in the brachial valve of LINGULA.

In SCHIZOTRETA (=ORBICULOIDEA, Davidson; see pp. 120, *et seq.*), we find a general correspondence in the character of these impressions, although our knowledge of the muscular scars of the brachial valve in that group is limited to a single species, *S. conica*, Dwight, and in this case only to the two large central scars, parted by a thickened median area and septum. In the absence of satisfactory evidence concerning these important characters in the brachial valve of ORBICULOIDEA, D'Orbigny, we may assume that their arrangement is indicated by what is known in the case of SCHIZOTRETA, a group very closely allied in other respects.

In the pedicle-valve of TREMATIS there is an apparent correspondence in the character of the pedicle-opening with the forms which have been referred above to ORBICULOIDEA, D'Orbigny. In the discussion of these fossils it has been shown that the aperture is not an oval perforation as in DISCINISCA, or a fissure extending to the margin as in TREMATIS, but a tubular oblique passage, most closely allied to that in SIPHONOTRETA. The homology in this respect then becomes remote, though distinctly traceable through the aberrant *Discina* (*Œhlertella*) *pleurites*, and perhaps is even more direct in the case of LINDSTRŒMELLA. SCHIZOBOLUS, DISCINOLEPIS, SCHIZOCRANIA and perhaps KUTORGINA conform with TREMATIS in having the aperture a radial incision, and as the nature of the pedicle-opening must be considered as of radical importance in determining the taxonomy of the inarticulate genera, the groups named will fall into close contiguity. It has been shown how closely SCHIZOBOLUS is allied to OBOLELLA in the character of its muscular anatomy, and that KUTORGINA probably represents an incipient stage in the development of the Siphonotretoid pedicle-tube.

Of DISCINOLEPIS little is known except its external conformation, while SCHIZOCRANIA expresses the extreme result of this tendency to marginal development in the aperture, an effect which comes by the way of TREMATIS.

Two months after the publication of the term TREMATIS by SHARPE, D'ORBIGNY proposed the name ORBICELLA for similar fossils having a supposed punctated shell-structure and a convex pedicle-valve; but no typical example was cited by him until, in his "Prodrome de paléontologie stratigraphique,"* nine species were referred to his genus, the first of which is the *Orbicula Buchi* of VERNEUIL.† It appears evident that D'ORBIGNY'S comprehension of his genus was equivalent to that of SHARPE for TREMATIS, as in his list both *Orbicula terminalis*, Emmons, and *O.? punctata*, Sowerby, are cited. It is necessary, however, to take *Orbicula Buchi* as the type of the ORBICELLA, and it does not appear from VERNEUIL'S description that this species is congeneric with *Trematis terminalis*. No mention is made of a punctated external layer, though this may have been accidentally absent in VERNEUIL'S specimens; the fissure is described as lanceolate and not extending to the border.‡

It has been observed elsewhere that this *Orbicula Buchi* is the species taken by PANDER in 1861 as the type of his genus KEYSERLINGIA (see page 117), and that by a strict construction of the rules of precedence, ORBICELLA must stand in place of PANDER'S term. Thus while D'ORBIGNY'S ORBICELLA, under the author's conception of the group, is synonymous with TREMATIS, and must be abandoned in this connection, it is rehabilitated as a genus by PANDER'S investigations.

The genus TREMATIS appears to be largely confined to American Silurian faunas. The published evidence in regard to the character of the pedicle-aperture in all the British species referred to this genus in the lists accompanying DAVIDSON'S General Summary (*T. Siluriana*, Davidson, *T. punctata*, Sowerby,

* 1849, p. 29.

† Géol. Russie d'Europe et des mont. de l'Oural, p. 228, pl. xix, fig. 1. 1845.

‡ It may be noticed that Mr. DAVIDSON'S elegant figure of *Trematis punctata*, as well as the description of the same species (British Silurian Brachiopoda, p. 69, pl. vi, fig. 9*a*), gives the pedicle-fissure the same character; probably an error arising from imperfect preservation of the specimens, but in case the character of the pedicle-aperture has been correctly represented, the species can not be congeneric with *Trematis terminalis*.

and *T. corona*, Salter; *T. cancellata*, Sowerby, does not appear in the catalogue), is meager and extremely unsatisfactory, though we may assume that the uncertainty in regard to these points will soon be cleared away. BARRANDE'S *Trematis Bohemica** is unquestionably a DINOBOLUS. At present we are able to recognize eleven species as undoubtedly congeneric, in addition to which are three of questionable affinity which are little known. All these are confined to the Trenton and Hudson faunas of the Silurian, and the earliest to appear is BILLINGS' *T. Huronensis*, from the Black River limestone.

The list of species is as follows:

Trematis terminalis, Emmons.
Trematis Montrealensis, Billings.
Trematis Ottawensis, Billings.
Trematis Huronensis, Billings.
Trematis millepunctata, Hall.
Trematis punctostriata, Hall.
Trematis crassipuncta, Ulrich.
Trematis quincuncialis, Miller and Dyer.
Trematis umbonata, Ulrich.
Trematis fragilis, Ulrich.
Trematis oblata, Ulrich.
? *Trematis pustulosa*, Hall.
?? *Trematis rudis*, Hall,=SCHIZOCRANIA (?).
?? *Trematis Dyeri*, Miller.

GENUS SCHIZOCRANIA, HALL and WHITFIELD. 1875.

PLATE IV G, FIGS. 21-35.

1847. *Orbicula*, HALL. Palæontology N. Y., vol. i, p. 99, pl. lxxx, figs. 9 a-d.
1863. *Trematis*, BILLINGS. Rept. Progress Canadian Geological Survey, p. 159, fig. 126.
1873. *Trematis*, HALL. Twenty-third Rept. N. Y. State Cab. Nat. Hist., Expl. pl. xiii, figs. 21, 22.
1875. *Schizocrania*, HALL and WHITFIELD. Geol. Ohio; Palæont., vol. ii, p. 73, pl. i, figs. 21, 22.
(?) 1878. *Trematis (Schizocrania)*, BARRETT. Ann. New York Academy of Sciences.
1884. (*Discinocaris?*), DAVIDSON. General Summary of the British Brachiopoda, p. 352.

DIAGNOSIS. Shells sub-circular in outline, inequivalve, unarticulated. Pedicle-valve flat or concave; apex subcentral. A deep triangular notch extends from just behind the beak to the margin, where its arc is equal to about one-sixth of the periphery. The apex of this broad pedicle-notch is occupied by a triangular transverse plate varying in size with the age of the shell, but extending for one-fourth to one-third the length of the opening. Surface marked by concentric growth-lines. On the interior no muscular impressions are vis-

* Syst. Sil. Bohême, vol. v, pl. 94, fig. vi. 1879.

ible. Brachial valve more or less convex, with the beak marginal. External surface radiately striated. The interior bears a pair of strong posterior adductor scars, lying close together in the umbonal region: their outline is elongate-ovate, indicating a progressive increase in size, and they frequently appear to be divisible into anterior and posterior elements. In front of them, at about the center of the valve, are the small and faint anterior adductor impressions. A low median ridge extends from the apex to beyond the center of the valve. External surface marked by elevated striæ radiating from the beak.

Substance of the shell composed of perlaceous calcareous laminæ which constitute the most of the shell. The inner layers appear to be corneous. All are impunctate (?).

Type, *Schizocrania filosa*, Hall.

Observations. We have knowledge of but two clearly defined species of this remarkable genus, the type, a not uncommon form in the Hudson group in Ohio and Kentucky, usually occurring attached to foreign bodies, not infrequently to valves of *Strophomena alternata;* a shell often of considerable size in these localities but represented in the Utica slate of New York by a rather diminutive form; and a second species, here described under the name *S. Schucherti*, from the Utica horizon of the Cincinnati group at Covington, Kentucky. It was observed in the original discussion of this genus that these fossils were probably parasitic or adherent by the surfaces of their lower valves, as in the case of most palæozoic Cranias. It seems necessary to modify this opinion as our present material affords evidence that the lower surface of the pedicle-valve retains its concentric markings with no trace of conformation to the body to which the animal may be attached. The pedicle itself was, if we may judge from the size of the aperture, of very great strength and the pedicle-valve, being of somewhat less diameter than the brachial, was overlapped by it, and it is very apparent that this overlapping edge of the upper valve has formed an important accessory means of attachment. (See Plate IV G, figs. 25, 29, 33–35.)

It is also frequently observed that attached shells from which the upper portion of the brachial valve has been broken, show the lower valve to have slipped out of its normal position without being able to escape from the internal cavity of the shell. Furthermore, the *Schizocrania filosa* of the Utica slate of New York is usually found free, and of thirteen examples before us of *S. Schucherti*, none are attached; which facts together induce us to believe that a parasitic habit requiring the modification of either valve to any such degree as in CRANIA, can not properly be considered a character of the genus.

The transverse plate in the apex of the notch in the pedicle-valve is directly comparable to the similar structure in *Œhlertella pleurites*, and is undoubtedly homologous with the external pedicle-groove seen in ORBICULOIDEA and SCHIZOTRETA. In SCHIZOCRANIA it has formed a surface over which the pedicle passed, increasing in size with age and becoming a conspicuous feature in old shells. The plate is not elevated or depressed above the plane of the valve as it is in *Œ. pleurites*, but it shows the median ridge projecting at the margin, a feature which is strongly marked in the latter species. (See discussion of ŒHLERTELLA on pages 120, *et seq.*)

In addition to the two species of the genus mentioned as occurring in the fauna of the Hudson group, are two other species in the Lower Helderberg fauna, less completely known but giving indications of structure similar to that of *S. filosa.* These are the form described in the Supplement to this volume as *S.* (?) *Helderbergia*, sp. nov., and that mentioned by BARRETT in the citation above given as *Trematis* (*Schizocrania*) *superincreta.* The species described as *Trematis rudis*, Hall, from the Trenton limestone at Clifton, Tennessee, is also imperfectly known, but may prove a SCHIZOCRANIA.

GENUS CRANIA, RETZIUS. 1781.

PLATE IV H, FIGS. 1-35.

1732. *Numulus*, STOBŒUS. Dissertatio epistolica.
1760. *Anomia (partim)*, LINNÉ. Systema Naturæ, Ed. x, p. 700.
1776. *Ostracites*, Benth. Juliæ et Montium subterranea, etc.
1776. *Patella*, MÜLLER. Zoologiæ Danicæ Prodromus.
1778. *Numulus*, WALLER. Systema Mineralogicum, vol. ii, p. 500.
1781. *Crania*, RETZIUS. Schriften der Berlin. Gesellsch. naturforsch. Freunden, vol. ii, p. 72.
1791. *Criopus*, POLI. Testacea utriusque Siciliæ, etc., vol. i, p. 34.
1795. *Criopoderma*, POLI. Testacea utriusque Siciliæ, etc., vol. ii.
1798. *Orbicula*, CUVIER. Tableau élémentaire de l'histoire nat. des animaux, p. 435.
1799. *Orbicula*, LAMARCK. Prodrome, p. 83.
1806. *Orbicularius*, DUMERIL. Zoologie analytique, p. 168.
1820. *Craniolites*, SCHLOTHEIM. Die Petrefaktenkunde auf ihr. jetz. Standpunkt, p. 247.
1849. *Crania*, *Criopus*, KING. Mongr. Permian Fossils of England.
1854. *Choniopora*, SCHAUROTH. Zeitschr. der deutsch. geol. Gesellsch., vol. vi, p. 546.
Crania, of recent writers generally.

(?) 1847. *Orbicula*, HALL. Palæontology N. Y., vol. i, p. 23.
(?) 1856. *Orbicula*, EMMONS. American Geology, p. 112.
1859. *Crania*, SHUMARD. Trans. St. Louis Academy of Sciences, vol. i, p. 395.
1860. *Crania*, HALL. Canadian Naturalist and Geologist, vol. v, p. 144.
1860. *Crania*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., pp. 77-79.
1862. *Crania*, HALL. Fifteenth Rept. N. Y. State Cab. Nat. Hist., pp. 182, 183.
1863. *Crania*, HALL. Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 31.
1863. *Crania*, HALL. Trans. Albany Institute, vol. iv, pp. 208, 209.
1865. *Crania*, WHITE. Proc. Boston Soc. Nat. History, pp. 29, 30.
1866. *Crania*, WINCHELL. Rept. Lower Penin. Michigan, p. 92.
1866. *Crania*, HALL. Pamphlet: Advance sheets Twenty-fourth Rept. N. Y. State Mus. Nat. Hist.
1867. *Crania*, WHITE and ST. JOHN. Trans. Chicago Acad. Sci., vol. i, p. 118.
1871. *Crania*, DALL. Bull. Mus. Comp. Zoology, vol. iii, No. 1, p. 27.
1872. *Crania*, HALL and WHITFIELD. Twenty-fourth Rept. N. Y. State Mus. Nat. Hist., p. 187.
1873. *Crania*, HALL and WHITFIELD. Twenty-third Rept. N. Y. State Cab. Nat. Hist., p. 236.
1874. *Crania*, DERBY. Bull. Cornell University, vol. i, No. 2, p. 60.
1874. *Crania*, BILLINGS. Palæozoic Fossils, vol. ii, p. 15, fig. 5.
1875. *Crania*, MILLER. Cincinnati Quarterly Journal of Science, vol. ii, p. 13.
1875. *Crania*, HALL and WHITFIELD. Geology of Ohio; Palæontology, vol. ii, pp. 74, 75.
1875. *Crania*, HALL and WHITFIELD. Twenty-seventh Rept. N. Y. State Mus. Nat. Hist.: Expl. pl. ix, figs. 36, 37.
1875. *Crania*, NICHOLSON. Rept. Palæontology Province of Ontario, p. 82.
1878. *Crania*, ULRICH. Journal Cincinnati Soc. Nat. Hist., vol. i, pp. 98, 99.
1879. *Crania*, HALL. Transactions Albany Institute, vol. x: Abstract, p. 13.
1879. *Crania*, HALL. Palæontology N. Y., vol. v, pt. ii, pl. lxxxviii, fig. 2.
1879. *Crania*, JAMES. The Palæontologist.
1879. *Crania*, HALL. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., p. 148, pl. xxi, figs. 8-10.
1880. *Crania*, N. H. WINCHELL. Eighth Ann. Rept. Geological Survey of Minnesota, p. 63.
1881. *Crania*, HALL. Eleventh Ann. Rept. State Geologist Indiana, pp. 282, 283, pl. xxvii, fig. 1.
1882. *Crania*, WHITFIELD. Description of New Species of Fossils from Ohio, p. 229.
1883. *Crania*, GURLEY. New Carboniferous Fossils.

1884. *Crania*, White. Thirteenth Rept. State Geologist Indiana. p. 121.
1884. *Crania*, Spencer. Bull. No. 1, Mus. Univ. State of Missouri, p. 57.
1886. *Crania*, Ringueberg. Bull. Buffalo Soc. Nat. History, vol. v, pp. 16, 17.
1889. *Crania ?* Walcott. Proceedings United States National Museum, 1888, p. 441 ; Advance sheets.
1889. *Crania*, Beecher and Clarke. Memoirs N. Y. State Museum, vol. i, No. 1, p. 13.
1889. *Crania*, Nettelroth. Kentucky Fossil Shells, p. 2.

Diagnosis. Shell inequivalve, inarticulated, without perforation for a pedicle; subcircular in outline, generally somewhat transverse across the posterior margin; attached by the apex or the entire surface of the lower valve. Ventral or lower valve depressed-conical or conforming to the surface to which it is attached. Dorsal or upper valve more or less conical with a subcentral, posteriorly directed apex. External surface of the valves usually smooth, sometimes spinose or with concentric or radiating striæ. In the interior of both valves are two pairs of large adductor scars, the posterior of which are close upon the margin and widely separated, the anterior near the center of the shell and close together, more approximate in the lower than in the upper valve. These posterior scars are often strongly elevated on a central callosity which surrounds their anterior margins. The margin of the lower valve is usually broad and thickened. Impressions of the pallial genital canals coarsely digitate.

Shell-substance calcareous; strongly punctated by vertical canals which become subdivided toward the epidermal surface.

Type, *Crania craniolaris*, Linné.

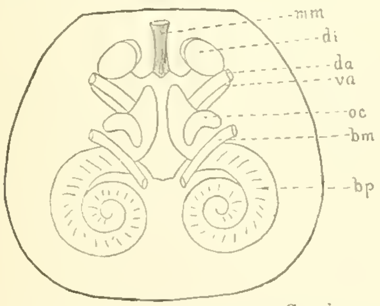
Observations. Crania is remarkable for presenting an association of shell-characters which have undergone no essential change from the earliest known appearance of the genus in Lower Silurian faunas to the present. Indeed neither palæozoic nor recent species indicate material variation from the type of internal structure found in *C. craniolaris*, while certain Mesozoic forms (*C. Parisiensis*, Defrance, from the Jurassic, *C. tripartita*, Münster, of the Cretaceous, etc.), give evidence of so great departure from the type in the development of internal diverging septa, in one or both valves, that separate subdivisions have been established for their reception; viz., Ancistrocrania and Craniscus, Dall, respectively.

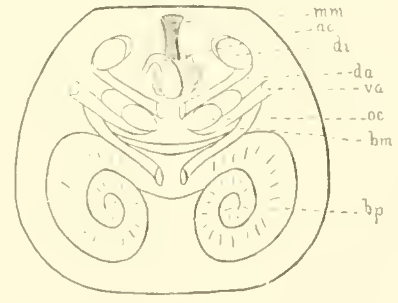
The degree of attachment of the lower valve has been made a basis of sub-

division by some authors. KING* proposed to limit the term CRANIA to such species as are attached by the umbonal portion of the lower valve, *e.g.*, *C. Ignabergensis*, and to apply the name CRIOPUS, which had been proposed by POLI in 1791 (*loc. cit.*) for the animal of CRANIA and some other brachiopods, to species attached by the entire surface of this valve. It is a well known fact that many species of CRANIA were quite unattached during their mature life, and other species are known to have been either attached or free. It therefore appears injudicious to ascribe a high value to so variable a character as the degree of attachment of the lower valve.

Among Cranias generally there is a more or less distinctly developed tendency to the formation of a transverse posterior or cardinal margin, a feature reaching an extreme in WAAGEN'S genus, CARDINOCRANIA.

It is not usual to find among palæozoic species any indication of more than two pairs of muscular impressions, the posterior being divaricators and the anterior, occlusors or adductors. The other small muscular bands rarely leave discernible scars, but their position may be learned from the accompanying figures of *Crania anomala*, Müller, reproduced from Dr. DAVIDSON'S Monograph of Recent Brachiopoda,† and made from sketches by Mr. ALBANY HANCOCK.





Crania anomala. After HANCOCK.

FIG. 66. Dorsal surface of the animal. FIG. 67. Ventral surface.

mm, mesenteric muscle; *di*, divaricators; *da*, dorsal adjustors; *va*, ventral adjustors; *oc*, occlusors; *bm*, brachial muscles; *bp*, brachial process; *ac*, alimentary canal (According to JOUBIN, this organ should have a median, not lateral termination).

In addition to the large muscular bands are three pairs of smaller ones; *da*, *va*, the dorsal and ventral adjustors respectively, and *bm* the brachial muscles,

* Monograph of the Permian Fossils of England, p. 84. 1849.

† Trans. Linnean Soc. London, vol. iv, pt. 3, p. 187. 1888.

which, according to HANCOCK, have both their extremities attached to the same valve (dorsal): *mm* is the median or mesenteric muscle, probably acting as a support to the viscera. Mr. DAVIDSON has given figures of a dorsal valve of *Crania* (*Pseudocrania*) *divaricata*, in which these minor impressions are shown,* and they may be seen more or less distinctly on some of the accompanying figures on Plates IV H and IV I.

The external surface of the upper valve in palæozoic Cranias is either smooth, that is with only the concentric lamellose growth-lines; covered with radiating, elevated, frequently dichotomizing costæ; or minutely spiniferous. In the first mentioned condition the surface is very generally modified by the contour of the body to which the lower valve is attached, and in most of these smooth species there appears to have been great indifference as to the zoological nature of the host. For example, *C.* (*Craniella*) *Hamiltoniæ* is shown upon Plate IV I to bear the surface-characters of *Tropidoleptus carinatus*, *Spirifer audaculus*, *Microdon* (*Cypricardella*) *bellistriatus*, and it is often found on other species of mollusca, and rarely upon trilobites and corals. Among the smooth forms occurring in the Hudson fauna in Ohio and Kentucky, are several to which various specific names have been applied in accordance with the modification of the surface from attachment to different hosts; *C. scabiosa*, Hall, often with a considerable degree of convexity and a smooth exterior, usually adheres to *Strophomena alternata*, or some species of ORTHIS, and to individuals having the parallel markings corresponding to the striæ of those shells, Mr. ULRICH has given the name *C. parallela*. Less frequently the same species attaches itself to gastropod shells of the genera PLEUROTOMARIA, CYCLONEMA, etc., or to small crinoid stems, or to the surface of monticuliporoid corals, undergoing in each case just such modifications as the circumstances have required. These variations pass under the names *C. percarinata*, Ulrich, *C. socialis*, Ulrich, and *C. multipunctata*, Miller, a subdivision wholly based on accidental characters. Indeed, among most of the smooth species in palæozoic faunas, unless there is some evident difference in interior character, a specific designation can hardly serve a broader purpose than to indicate a different association. The plicate or

* British Silurian Brachiopoda, pl. viii, figs. 11, 11 a, 12 a.

spiniferous Cranias never evince more than a very slight tendency to surface modification from attachment.

The shell-structure in this genus is essentially calcareous and composed of two layers, the inner of which is the thicker, the outer being thin, dark colored, epidermal. It is strongly punctated by vertical tubules, the openings of which

FIG. 68. Vertical section of the shell of the upper valve of *Crania anomala* (after KING), showing the arborescence of a tubule on approaching the outer surface.

FIG. 69. Horizontal section just below the upper surface. After KING.

on the internal surface may, under good preservation, be seen with the naked eye. It has been shown by CARPENTER,* KING† and JOUBIN,‡ that these tubules are widest at their inner extremities, and as they reach the epidermal layer in the upper valve they ramify and become aborescent, making an irregular plexal opening on the surface. From JOUBIN's observations this aborescent character does not appear to exist in the attached valve.

In respect to muscular anatomy there is little reason to doubt the closer relation of CRANIA to DISCINA and DISCINISCA than to any other of the inarticulates. The four large impressions in each genus occupy correlative positions, and though Mr. DAVIDSON terms the posterior pair in *Crania* (*Pseudocrania*) *divaricata*, divaricators, and those in DISCINISCA, adductors, we can find no authority for ascribing different functions to the muscles they represent. But in the entire absence, in any stage of the development of the shell, of pedicle or foramen, and in the calcareous nature of the shell-substance, CRANIA stands far apart from all other members of the class; and JOUBIN has observed that it is the only known brachiopod which has the anal opening exactly in the median line.

There is no evidence that CRANIA has been a member of faunas older than the Silurian, and no indubitable proof of its appearance earlier than the Tren-

* On the Intimate Structure of the Shells of the Brachiopods: DAVIDSON's Introduction to British Fossil Brachiopoda, chap. ii.

† On the Histology of the Test of the Class Palliobranchiata: Trans. Royal Irish Academy, vol. xxiv.

‡ Recherches sur l'Anatomie des Brachiopodes Inarticulés: Archives de Zoologie Expérimentale, t. iv. 1886.

ton. The *Crania? Columbiana*, Walcott, from the primordial beds of the Mt. Stephen section, British Columbia, is thus referred from external characters only; the imperfectly known fossil described in vol. i of the Palæontology of New York (p. 23), as *Orbicula deformata*, from the Chazy limestone, has an exterior suggestive of CRANIA, but may be a discinoid. The earliest clearly defined species are *C. Trentonensis*, Hall, and *C. setigera*, Hall, from the Trenton fauna; throughout the Palæozoic the genus fails to reach a very abundant development in species, though in some faunas these species were very prolific in individuals. The number of recognizable species now known from American palæozoic rocks will not exceed thirty.

A few words are necessary in regard to the type-species of CRANIA. According to DALL,* RETZIUS confounded under the name *C. Brattensburgensis*, the *Numulus Brattensburgensis* of STOBŒUS, 1732, the *Anomia craniolaris* of LINNÉ, 1760, and a recent species believed to be the *Patella anomala* of MÜLLER, 1776. DAVIDSON adopted the term *C. Brattensburgensis*, Stobœus, not Retzius, as the typical species, but as it has been conceded by most authors that this is identical with LINNÉ'S *Anomia craniolaris*, DALL would make the latter stand as the designation of the type on the ground that STOBŒUS was not a binomial author. Under the discussion of the genera DISCINA, ORBICULOIDEA, etc., attention has been called to the fact that the ORBICULA of CUVIER, established on the *Patella anomala* of MÜLLER, is a synonym for CRANIA wherever used by authors in the Cuvierian sense. The ORBICULA of SOWERBY, 1822, and wherever the term has been used by other authors with the same meaning, is synonymous with "DISCINA" (= ORBICULOIDEA, D'Orbigny).

The term CHONIOPORA was applied by SCHAUROTH† to a Permian fossil considered by him as representing a new generic form of Bryozoan. It was subsequently shown by GEINITZ‡ that the fossil to all external appearances is a CRANIA with radiately striated and granulated surface, and was described

* Bulletin Museum Comparative Zoology, vol. iii, No. 1, p. 30.

† Zeitschr. der deutsch. geolog. Gesellschaft, vol. vi, p. 546. 1854.

‡ Dyas, Heft. I, p. 109. 1861.

by him as *C. Schaurothi.* DALL suggests* that the species may represent a valid subdivision of the genus CRANIA; but while the interior remains unknown, and the exterior is so similar to that of such species as *C. setifera*, *C. setigera* and *C. spinifera*, it would seem injudicious to assign it a distinct generic position.

The generic term PSEUDOCRANIA, McCoy (Annals Nat. Hist., Second Series, vol. viii, p. 387), was proposed in 1851. The following diagnosis was given in British Palæozoic Fossils, p. 187. 1855:

"Shell slightly inequivalve, free; both valves regular, depressed, subconical, unattached; dorsal valve with or without a small cardinal area; internally, margin broad, flat, smooth or minutely striated concentrically; anterior pair of muscular impressions much larger and more strongly marked than the posterior pair; pallial impressions numerous, linear, not interrupted along the middle.

"This palæozoic genus differs from the true Craniæ in the following points: (1) CRANIA is attached by the substance of the dorsal valve, and exhibits thereon an irregular scar; both valves are free and regular in PSEUDOCRANIA: (2) in CRANIA the posterior or marginal pair of adductor muscles are always larger and deeper than the medial or anterior pair; the reverse is remarkably the case in the present genus, which also has a smooth or minutely striated margin, destitute of the strong granulation and punctures of most Craniæ. The *Crania antiquissima*, as given by VERNEUIL, may be taken as a type of the genus, as also the following species" (*Pseudocrania divaricata*, McCoy.)

Pseudocrania divaricata.
After DAVIDSON.
FIG. 70. Interior of upper valve: *a*, adductors; *l*, adjustors; *m*, mesenteric; *r*, divaricators; *n*, brachials.
FIG. 71 Interior of lower valve.

The first of these typical species, the *Orbicula antiquissima*, Eichwald,† = *Crania antiquissima*, Verneuil,‡ as represented by the latter author, shows a close similarity to PHOLIDOPS, Hall, in the character of its muscular scars. These are delineated as two central impressions abutting against a conspicuous posterior callosity, no evidence appearing of any posterior marginal scar corresponding to the posterior adductors or divaricators of CRANIA. Mr. DAVIDSON§ subsequently demonstrated

* Bulletin No. 8, U. S. National Museum, p. 19.

† Silurian System in Esthland, p. 169. 1840.

‡ Géol. de la Russ. de l'Europe, etc., p. 289, pl. i, fig. 12. 1845.

§ Silurian Brachiopoda, p. 79.

the existence of these posterior scars in the Russian species and was inclined to regard the specific difference in the *Orbicula antiquissima* and *Pseudocrania divaricata* as not great. With PHOLIDOPS, therefore, they can agree only in the fact of being unattached shells, the two distinct pairs of muscular impressions on the inside and, in *P. divaricata*, the posterior beak and radiating ornamentation on the exterior, separating them definitively from this genus. The features upon which McCOY proposed to separate these species from CRANIA should not be given too great importance; the unattached habit of the shells throughout their existence may prove of value as a basis for a section of the genus CRANIA, but the fact that the central muscular impressions are often larger than the anterior, will not hold good for these forms only, as it is often seen in the American species of CRANIA. We are disposed to agree with Mr. DAVIDSON in regarding PSEUDOCRANIA as synonymous with CRANIA. *Pseudocrania divaricata* is from the Bala limestone and Llandeilo flags; *P. antiquissima* from the Vaginaten-kalk, near St. Petersburg.

EICHWALD,* in 1860, proposed to designate the species, *Orbicula antiquissima*, by the term PALÆOCRANIA, as it differs from *Pseudocrania divaricata* in the central position of the beak and the concentric markings of the shell. This proposal however is illegitimate, as *O. antiquissima* was the first type of PSEUDOCRANIA and therefore is not available as the basis of another genus.

Should these two species not prove congeneric either with each other or with CRANIA, EICHWALD'S term will, under any circumstances, prove inadmissible. When the *Orbicula antiquissima* becomes better known it may furnish a satisfactory foundation for PSEUDOCRANIA as a genus.†

* Lethaea Rossica, vol. i, p. 909.

† The only American species which has been referred to PSEUDOCRANIA is the *Crania* (*Pseudocrania*) *anomala* of A. WINCHELL, from the Hamilton group (Rept. Grand Traverse Region of Michigan, p. 92. 1866). By the favor of Professor WINCHELL we have been allowed to examine specimens agreeing with the original description, and are compelled to pronounce the name a misnomer, as the species is a well defined streptorhynchoid.

Genus CRANIELLA, Œhlert. 1888.

PLATE IV I, FIGS. 1 16.

1888. *Craniella*, Œhlert. Bull. de la Soc. d'Études scientif. d'Angers, p. 37. 1887.
1889. *Craniella*, Kayser. Abhandl. der Königl. Preuss. geol. Landesanstalt, Neue Folge, Heft i, p. 65.
Crania, in part, of several authors.

Diagnosis. "Shell somewhat irregular, outline subcircular or subquadrangular. Ventral valve thin, adhering by its entire surface; dorsal valve conoidal, more or less elevated; apex subcentral, posterior; interior of the dorsal valve without a well defined border; impressions of the adductors large, very distinct, four in number, of which the posterior two are quite distant, the two subcentrals somewhat smaller, closely approximate or even confluent; from near each of the posterior impressions starts a vascular sinus, which is broad, strongly sinuous near its point of departure, narrowing gradually in following the contour of the valve, emitting from its marginal side dichotomizing secondary branches." (Œhlert, *loc. cit.*)

Fig. 72. *Craniella Meduanensis*
After Œhlert.
Internal cast of upper valve.

Type, *Craniella Meduanensis*, Œhlert.

Observations. With the peculiar sigmoid vascular sinuses in the upper valve as a distinctive character, we are disposed to regard this genus as well grounded. This character is observed in an interesting species, *Craniella Ulrichi*, sp. nov., from the Trenton limestones at Minneapolis, Minnesota, and in the common *Crania Hamiltoniæ* of the Hamilton shales, and undoubtedly will be found to be far more generally distributed as the interior features of the palæozoic Cranias become better known. To the degree of attachment of the lower valve we should ascribe less importance than does Dr. Œhlert. The Trenton species mentioned is sometimes attached and evidently as often free, while *C. Hamiltoniæ* appears to be, like *C. Meduanensis*, invariably adherent by the entire surface of the lower valve.

GENUS CARDINOCRANIA, WAAGEN. 1885.

1885. *Cardinocrania*, WAAGEN. Mem. Geol. Surv. India; Palæont. Indica, Ser. xiii, vol. i, iv (fas. 5), p. 745.

Type, *Cardinocrania Indica*, Waagen, *loc. cit.*, pl. lxxxiv, figs. 1, 2.

These very peculiar shells, of which only attached valves are known, have a straight hinge-line which is set off from the remaining outline of the shell by strong post-lateral indentations, giving the valve somewhat the outline of the alate strophomenoids, or still more suggestive of the attached valve of RICHTHOFENIA (see figures of *R. Lawrenciana*, Koninck, *op. cit.*, plate lxxxiii, figs. 1, a, b, c). This hinge, however, is always edentulous, and is an extreme specialization of the feature usually apparent as a transverse posterior line in most of the Cranias. "In the interior of the valve the most conspicuous part is a thin, triangular shelly plate, fixed by its broad base to the cardinal region of the valve, and extending with its narrow and indented extremity to not far from the front. It is supported in the middle by a low septum." (WAAGEN, *op. cit.*) The arrangement of the muscular scars has not been observed; notwithstanding, the known characters of the shells substantiate the generic difference from CRANIA. The single known species is from the Permo-Carboniferous beds of Salt-Range of India.

Cardinocrania Indica, Waagen.
After WAAGEN.
FIGS. 73, 74. Interiors of attached valves.

PHOLIDOPS, Hall. 1859.

PLATE IV 1, FIGS. 17-37.

1820. *Patellites*, Schlotheim. Die Petrefaktenkunde auf ihr. jetzig. Standpunkt.
1839. *Patella* (?), Sowerby. Murchison's Silurian System, p. 625, pl. xii, fig. 14 a.
1843. *Orbicula*, Hall. Geology of New York; Report Fourth District, p. 168, fig. 1
1847. *Orbicula*, Hall. Palæontology of New York, vol. i, p. 290, pl. 79, figs. 7 a, b.
1852. *Orbicula ?*, Hall. Palæontology of New York, vol. ii, p. 250, pl. 53, figs. 4 a, b.
1855. *Orbiculoidea*. McCoy. British Palæozoic Fossils, p. 189.
1859. *Craniops*, Hall. Twelfth Rept. N. Y. State Cab. Nat. History, p. 84.
1859. *Pholidops*, Hall. Palæontology of New York, vol. iii, pp. 489, 490.
1859. *Crania*, *Discina*, Salter. Murchison's Siluria, Second Edition.
1860. *Pholidops*, Hall. Thirteenth Rept. N. Y. State Cab. Nat. History, p. 92.
1862. *Pholidops*, Hall. Fifteenth Rept. N. Y. State Cab. Nat. History, p. 195.
1863. *Pholidops*, Hall. Sixteenth Rept. N. Y. State Cab. Nat. History, p. 31.
1863. *Pholidops*, Hall. Trans. Albany Institute, vol. iv, p. 209.
1866. *Pholidops*, Hall. Descriptions New Species Fossils, etc.; Advance sheets Twenty-fourth Rept. N. Y. State Mus. Nat. History.
1866. *Crania*. Davidson. British Silurian Brachiopoda, p. 80, pl. viii, figs. 13-18.
1867. *Pholidops*, Hall. Palæontology of New York, vol. iv, pp. 31, 32, 413, 414, pl. iii, figs. 1-11.
1871. *Pholidops*, Dall. Bull. Mus. Comp. Zoology, vol. iii, No. 1, p. 27.
1872. *Pholidops*, Hall. Twenty-fourth Rept. N. Y. State Mus. Nat. History, p. 221, pl. vii, figs. 8-10.
1873. *Pholidops*, Meek. Geol. Surv. Ohio; Palæontology, vol. i, p. 130, pl. v, figs. 2 a, b.
1879. *Pholidops*, Hall. Twenty-eighth Rept. N. Y. State Mus. Nat History, p. 149, pl. xxi, figs. 1, 2.
1881. *Pholidops*, Hall. Eleventh Ann. Rept. State Geologist Indiana, p. 284, pl. xxi, figs. 1, 2.
1883. *Pholidops*, Davidson. British Silurian Brachiopoda, Supplement, p. 216, pl. xvii, fig. 48.
1884. *Pholidops*. Walcott. Palæontology Eureka District, pp. 113, 114, pl. ii, figs. 6, 7.
1885. *Pholidops*. Verworn. Zeitschr. der deutsch. geol. Gesellsch., vol. xxxvii, p. 173.

Diagnosis. Shells small, patelliform, equivalve, equiconvex, inarticulate, unattached. Outline oval or subelliptical; apex subcentral, excentric or marginal, sometimes terminal and produced. Surface marked by strong, concentric, often lamellose lines of growth, which are crowded on the posterior, and distant on the anterior portions of the valves; these are sometimes crossed by faint interrupted radiating lines. In the interior, the surfaces of contact make a broad smooth, flat or slightly convex border, somewhat broader in front than behind. The muscular and visceral area occupies a sharply defined and very limited space in the apical portion of each valve. In both valves it is of essentially the same size and subtriangular in outline, the apex of the triangle pointing forward and usually surrounded by a conspicuous callosity.

The ventral (?) valve bears two well defined central adductors occupying the same relative position as in Crania; these impressions are usually simple, but

appear to be sometimes complicated by association with ill-defined scars of the anterior muscles. The posterior adductors or divaricators are situated at the basal angles of the muscular triangle, and are distant from the posterior margin. The linear parietal scars are very strong, the posterior being more or less distinctly lobate, the anterior generally straight or rounding about the central adductors. In the opposite or dorsal (?) valve the scars have essentially the same arrangement; the anterior adductors, however, are separated by elongate median scars (anteriors) which traverse the elevated callosity surrounding the anterior margin of the area. The posterior scars are often more widely divergent than in the other valve. Shell-substance calcareous and impunctate (?).

Type, *Pholidops squamiformis*, Hall.

Observations. This peculiar group of shells presents an interesting association of features which, so far as known, is susceptible to slight variation. The character of their muscular anatomy is distinctly cranioid, as seen in the development of the two strong pairs of adductor scars, but the concentration of the muscular impressions and the resulting removal of the posterior scars forward from the margin is a feature not seen in any Crania; added to this is the usually sharp impression of the parietal wall which is rarely observable in any of the inarticulates except the Trimerelloids. The posterior lobate limb of this impression in Pholidops is suggestive of the scalloped or sinused arch seen in Lingulops,* but we should hesitate to suggest an analogy between the two.

The depth of the muscular impressions in Pholidops, evidently an index of the strength of the muscular bands, is a natural result of their concentration within the confined visceral area, for by such a displacement a great advantage in the closing of the valves is sacrificed.

In external features, outline and contour, there occur some noticeable variations. The typical species, *P. squamiformis*, with oval outline and subcentral beak, represents the character of exterior prevailing among the species

* In discussing the genus Lingulops, we have indicated that the scar of the parietal wall constitutes the crown of the *crescent* and that there is no satisfactory reason for ascribing to the crescent in Lingulops one function, and to that in Trimerella another, as was done by Davidson and King.

generally, appearing in the earliest known representative, *P. Trentonensis*, and enduring until the genus disappears in the Lower Carboniferous. Among the forms which follow this type of exterior, it is often difficult to point out specific differences, variations in internal features accompanying the slight external changes in outline or convexity being as a rule difficult to establish. Thus the forms, *P. Trentonensis* from the Trenton limestone, *P. Cincinnatensis* from the Hudson group, *P. squamiformis* of the Niagara and Clinton groups, *P. ovata* of the Lower Helderberg, *P. bellula* of the Lower Devonian of the Eureka District, *P. lepis* of the Corniferous limestone, *P. Hamiltoniæ* of the Hamilton, and an undetermined species in the Waverly, and also *P. antiqua* of the Beyrichien-kalk of the Island of Gotland, present differences of slight value in any respect, but each occurs at a distinct horizon and serves to characterize the faunas of which they are respectively members.

A slight variation in external outline without essential change in interior characters is seen in the elliptical species, *P. ovalis* of the Niagara and in *P. implicata* of the Wenlock; and it is probable that these American and European forms are identical. A more extreme variation appears in the species, *P. terminalis* of the Oriskany sandstone, *P. calceola* of the Corniferous, *P. linguloides* and *P. oblata* of the Hamilton, where the apex is terminal and produced, the concentric striæ on the posterior limb of the shell making a sort of cardinal area. This extended umbo is solid and it remains to be ascertained whether it occurs on both valves alike.

In regard to the nomenclature of the two valves in Pholidops, the terms *pedicle* and *brachial* are inapplicable here as in Crania, on account of the absence of any pedicle-aperture in the mature shell. The conventional designations *ventral* and *dorsal*, which are virtually misnomers in their application to the brachiopoda, may serve to indicate a means of comparison with the attached ("ventral") and free ("dorsal") valves of Crania. With the latter, that valve in Pholidops is homologous which bears the median pair of narrow, elongate scars, traversing the anterior apex of the muscular callosity; these scars representing the distal anteriors found in the free valve of Crania (probably the anterior insertion of the brachial muscles), and shown very distinctly by

Davidson[*] in the "dorsal" valve of the free species, *Crania* (*Pseudocrania*) *divaricata*, McCoy. In the opposite valve of Pholidops these scars do not appear, and the interior margin of the callosity is uninterrupted In certain species, particularly those of large size which have been found as internal casts, the whole muscular area of the ventral (?) valve appears to be occupied by the scars of the anterior adductors (see Plate IV I, figs. 26, 36). The fact that in these cases the other muscular and the parietal scars are not defined is probably due to imperfect preservation.

The substance of the shells of Pholidops is calcareous and apparently impunctate. On account of their extreme tenuity it has been impossible to make satisfactory sections, but there appears by magnification of the surface no evidence of punctation. Should an impunctate character be demonstrated it will be another important respect in which Pholidops differs from Crania.

This group of shells was noticed as early as 1820 by Schlotheim, who, by the designation Patellites (*P. antiquus* of the Gotland Upper Silurian limestone) implied its relationship to Patella. Sowerby, in 1839, essentially coincided with this opinion in referring an English species to Patella (*P. implicata*). Thereafter, until 1859, the American species were placed under the genus Orbicula, a name which at that time had come to include a great variety of heterogeneous brachiopods, now mainly referred to Crania and Orbiculoidea. McCoy, however, in 1859, considered the English species congeneric with the Schizotreta of Kutorga, and, not recognizing the priority of the latter name, placed both in D'Orbigny's genus, Orbiculoidea. Salter, in 1859, and Davidson as late as 1866, referred *P. implicata*, Sowerby, to Crania, and though the latter author in 1883 corrects this reference and recognizes the term Pholidops, no modification was suggested of the figures given of the interior of this species in the British Silurian Brachiopoda (pl. viii, figs. 15, 16 a), which are radically incorrect in representing the valves with posterior marginal muscular scars. In 1859, in a revised list of the fossils described in the first two volumes of the Palæontology of New York, the term Craniops was proposed for the

[*] British Silurian Brachiopoda, pl. viii, figs. 11, 11 a, 12 a.

Niagara species *Orbicula? squamiformis*, though without further definition, but in Volume III of the Palæontology, published the same year, the genus was illustrated and defined under the name of PHOLIDOPS, the term CRANIOPS being unaccountably overlooked.

The relations of this genus to PSEUDOCRANIA, McCoy, and PALÆOCRANIA, Eichwald, have been elsewhere discussed.

Species of PHOLIDOPS are often abundant in American palæozoic faunas, their first appearance being, as already noticed, in the Trenton, and their latest known representative in the Bedford shales. It has already been observed that there exists a close specific similarity in some of the forms belonging to widely separated faunas, *e. g.*, *P. Trentonensis*, *P. Cincinnatensis*, *P. squamiformis*, *P. ovata*, *P. Hamiltoniæ* and *P.*, sp. (?), from the Trenton, Hudson, Niagara, Lower Helderberg, Hamilton and Waverly groups respectively, but it is indispensable to recognize them as distinct species. In strong contrast to this general prevalence of PHOLIDOPS in America, is the evident paucity of its representation in Europe, where occur only the *P. implicata*, in England, and the same species with *P. antiqua*, in Gotland, the former being regarded by some authors as synonymous with the latter.

NOTE TO PAGE 128.

The genus ORBICULOIDEA of D'ORBIGNY was first defined and exemplified in the Prodrome de Paléontologie, vol. i, p. 44, the date of this work being 1850, not 1849. DALL is in error in stating that *Orbicula Morrisi*, Davidson, is the first species mentioned under the diagnosis quoted. D'ORBIGNY here gives three species in the following order: *O. Forbesi*, Davidson, *O. Morrisi*, Davidson, *O. Davidsoni*, D'Orbigny. As no species is specially designated as the type of the genus we are compelled to assume these three as types in their order and upon their merits. It is shown on page 136 that the first of these, *O. Forbesi*, Davidson, is unquestionably congeneric with *Schizotreta elliptica*, Kutorga, KUTORGA's genus having been established in 1848. As this species, therefore, can not be used as the type of ORBICULOIDEA, we must assume the second species as the typical representative of the genus, and upon this is based the distinction throughout the foregoing pages in the use of this term ORBICULOIDEA by D'ORBIGNY and by DAVIDSON. At the place cited in the "Prodrome" the date "1847" stands after the name of the genus. The explanation of its use appears upon page lix of the Introduction, and the date of publication of the work renders its adoption untenable.

CONCLUSION.

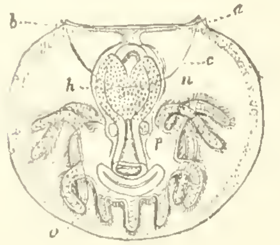
The consecutive treatment of a group of organisms whose natural relations can be properly expressed only by diverging lines or ramifications from some common stock, fails to indicate satisfactorily the relations of each part of the group with every other part. These must be pointed out by themselves after the characters of the various subdivisions have been described.

To avoid difficulties and unnecessary discussion, no recognition has thus far in this work, been accorded to family groups. The reasons for this will appear in the following. On the other hand it has seemed judicious, in order to make the generic discussions, as far as possible, homogeneous, to use as many terms of this value as are in any way justifiable. The future will undoubtedly demonstrate that some of these generic groups are still too broad.

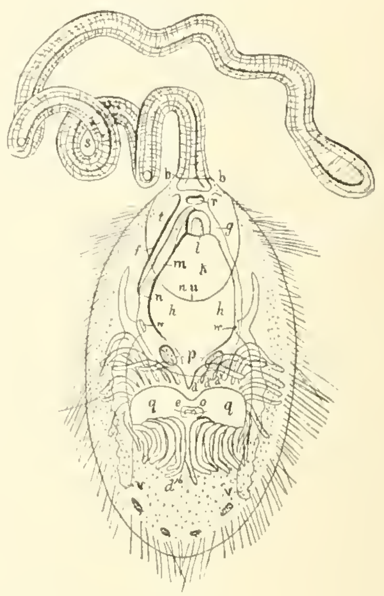
To regard the genus Lingula as taxonomically at the base of the brachiopoda, is a matter of custom. Against this position, nearly every feature of anatomy, development, and geological history is a protest. The muscular system of Lingula is extremely complicated, more so than that of any other of these inarticulate forms, and probably more than in any other generic group in the order of brachiopoda. In dealing with the fossil forms, the details of muscular arrangement are found to be frequently much obscured; we can not always be sure of our data, and under such conditions, it becomes important to subordinate apparent variations in the arrangement of muscular scars, as an element in establishing generic relations, to some feature subject to less variation from mode of preservation. This feature of paramount importance, we believe will be found in the character of the pedicle-passage.

Among the inarticulates, its variations in position and structure are extreme, and must have been accompanied by or have necessitated material changes in internal anatomy. On such a basis alone, Lingula, which has the posterior

margin of both valves modified for the passage of the pedicle between them, may take a position near the base of the system, and its elaborate muscular apparatus may establish it in such a position as a comprehensive type or point of departure for many derivatives.



a Hinge-teeth of brachial valve.
b Hinge teeth of pedicle-valve.
c. Semicircular plate of brachial valve.
d Median tentacle.
f. Parietal bands.
g. Body cavity.
h Liver
k Hepatic chamber of stomach.
l. Intestinal chamber of stomach.
m. Intestine.
n Anus.
o. Mouth.
p Muscles (primary).
q Lophophore.
r. Posterior unpaired muscle.
v. Pallial sinus.
w Its opening into the body cavity



Embryonic stages of *Lingula pyramidata*, Stimpson (= *Glottidia Audebarti*, Broderip). After Brooks.

Fig. 75. Dorsal view of the youngest larva observed. × 250.
Fig. 76. Dorsal view of a somewhat older embryo. × 250.
Fig. 77. Ventral view of an individual soon after becoming sedentary. *nu* indicates the edge of the larval shell.

The embryological history of Lingula, as elaborated by Brooks,* for *L. pyramidata* (= *Glottidia Audebarti*), has an important bearing upon the taxonomic position of this group. The author has shown that the shell in its earlier stages, has a subcircular form, and that the posterior opening for the pedicle is as fully developed on one valve as on the other; further, that the muscular bands first to appear are a great posterior or umbonal, and two simple transverse bands crossing the interior cavity (but not each other) near the œsophagus. The latter are regarded by Brooks as representing the muscles *h*, *j*, *k* and *l*, of the mature animal (see figs. 6, 7, page 10). All these features are apparent in shells of the obolelloids; the subcircular valves, the pedicle-passage, sometimes

* Chesapeake Zoological Laboratory; Scientific Results of Session of 1878.

clearly developed in the brachial as well as in the pedicle-valve, a large central (umbonal ?) muscular scar, and conspicuous, undifferentiated lateral scars.

The fact that the culmination of the obolelloid type was attained in faunas where LINGULA is not yet known, fortifies the view that LINGULA has been directly derived from this source. In LINGULELLA and LINGULEPIS may be found important connecting links, in which the external form of LINGULA is associated with the muscular arrangement and the narrow pedicle-slit of the obolelloids. These two genera are also forerunners of LINGULA.

By the attainment of the linguloid *ensemble*, a combination of characters was produced which was capable of adapting itself to all conceivable changes in its surroundings to an extent never recurring in the organic world. But while the development along the linguloid line has continued, as we believe, from early Silurian to the present time, modifications of this type were not infrequent. From LINGULA we may depart in many directions. A gradual increase in the secretion of testaceous matter about the insertions of the muscular and parietal bands, carries eventually to an extreme the development of median and lateral septa. One phase of this extreme, in which the septa are alike in both valves, is attained, in DIGNOMIA, as early as the Devonian; another, with some diversity in the septa of the opposite valves (and quite plausibly in the direct line of derivation from DIGNOMIA), appears first in the Mesozoic, and has continued to the present in GLOTTIDIA. The numerous forms in which the septa are more or less developed without attaining the condition in DIGNOMIA or GLOTTIDIA are better left within the proper limits of LINGULA.

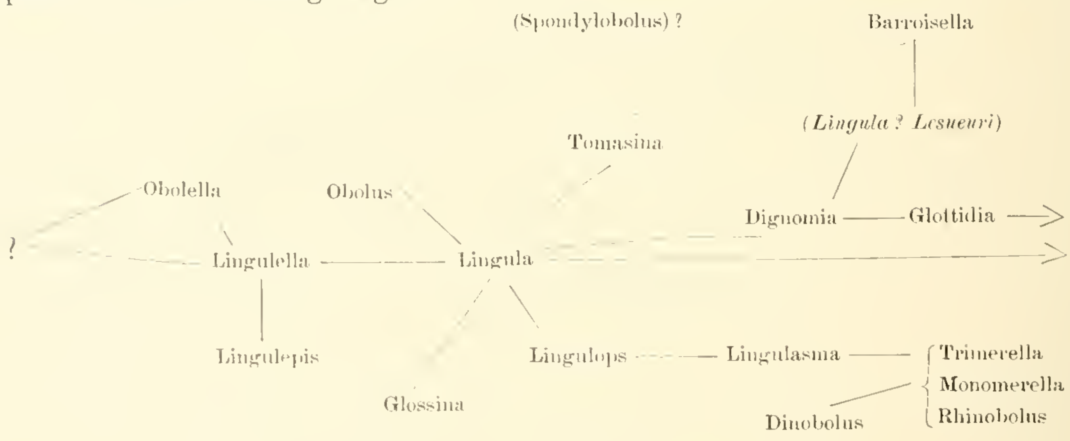
Again, the elevation of the anterior edges of the testaceous deposits about the bases of the central and lateral muscles, probably due, as we have elsewhere suggested (see pages 46–55), to displacement of, and pressure against the liver, has induced first, the thickening of the entire area of muscular implantation, followed by the gradual excavation of this solid plate and the formation of a more or less vaulted platform. Thus was begun the line of variations consecutive through LINGULOPS and LINGULASMA, the extreme of which is reached in TRIMERELLA. In the later Silurian sea the conditions appear to have been especially favorable to the rapid development of these platform-bearing species,

and the abrupt extinction of the entire group with the close of the Niagara-Wenlock period constitutes one of the most striking features in their history.

In BARROISELLA a considerable variation from LINGULA is found in the character of the internal markings, accompanied by the development of the deltidial callosities to such a degree as to indicate their specialization for purposes of articulation, and it is here that we find one of the most striking of the few instances observed among the brachiopods, of an evident tendency to span the interval between the so-called inarticulates and articulates. *Barroisella subspatulata* of the Genesee fauna affords the last phase in the development along this line; it had been preceded in Silurian faunas by the *Lingula? Lesueuri*, a form which has the articulating processes of BARROISELLA combined with the septal characters of DIGNOMIA or GLOTTIDIA.

Future investigation may show that the little-known SPONDYLOBOLUS is a similar resultant which has come by the way of OBOLELLA. The same tendency to the development of articular processes in the pedicle-valve is also observable, though to a less degree, in TRIMERELLA and MONOMERELLA, while the inception of a cardinal process in the opposite valve has repeatedly manifested itself. (See note on page 1.)

The immediate lines of derivation of, and departure from LINGULA are expressed in the following diagram:



Returning to the genus OBOLELLA, we find it also an important point of divergence.

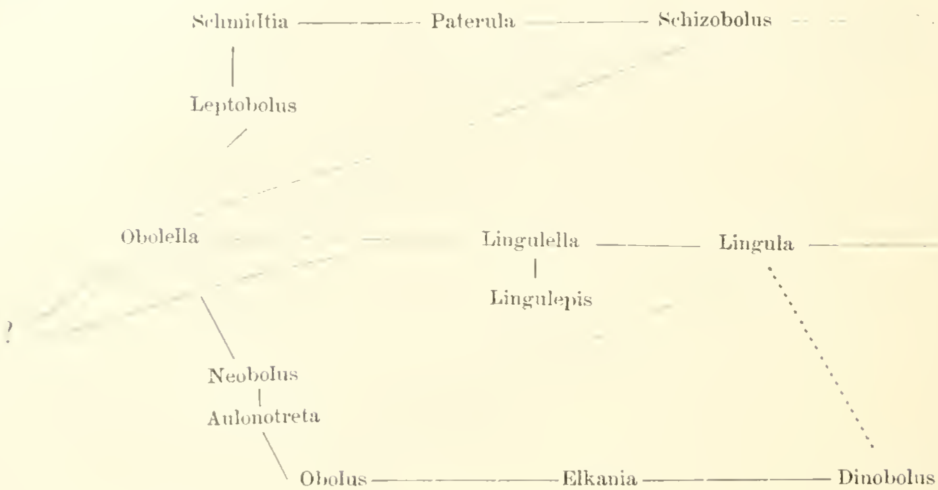
As suggested above, certain linguloid characters, in which form and the structure of the pedicle-passage are paramount, have departed toward LINGULA by the way of LINGULELLA. Another combination of linguloid features, in which the muscular scars are of primary importance, but the form still obolelloid, is represented by the genus OBOLUS. Here the muscular bands have become specialized to such a degree that in the pedicle-valve they approach closely to LINGULA, while in the other they retain more distinctly the obolelloid character; moreover, the subcircular form and the persistence of the pedicle-groove on both valves are features of OBOLELLA.

OBOLUS, therefore, is a more specialized form than OBOLELLA and less so than LINGULA. The aberrant NEOBOLUS appears to hold intermediate structural relations to both OBOLUS and OBOLELLA, except in the existence of a strong cardinal process in the brachial valve, a feature indicating progress in this line of derivation, toward characters of the articulate brachiopods.

The typical combination of obolelloid characters is continued, without essential variation, into the genera LEPTOBOLUS and SCHMIDTIA, while PATERULA, whose structure demonstrates its close alliance with LEPTOBOLUS, presents a new feature of great importance in its minute, incised, marginal pedicle-aperture. In SCHIZOBOLUS we find the same features superinduced upon the substantially unaltered muscular scars of OBOLELLA.

While discussing the origin and development of the platform in the inarticulate brachiopoda, we have referred to the fact, that OBOLUS, in having its muscular scars excavated, as in LINGULA, and not elevated on a central thickening, as in the other forms constituting the linguloid line of development toward TRIMERELLA, holds the same relation to the genus ELKANIA, as does LINGULA to LINGULOPS. Further, that ELKANIA represents, by virtue of this variation, an important progress in the development of trimerelloid characters along the obolelloid line, connecting with TRIMERELLA by way of DINOBOLUS. There is no single feature in the entire group of the edentulous brachiopods so striking as the great platform in TRIMERELLA and its allies, and it is rarely that so beautiful and well-established an illustration of the attainment of such a remarkable resultant along two distinct lines of development can be presented.

The immediate variations from the obolelloid stock, may be expressed as follows:

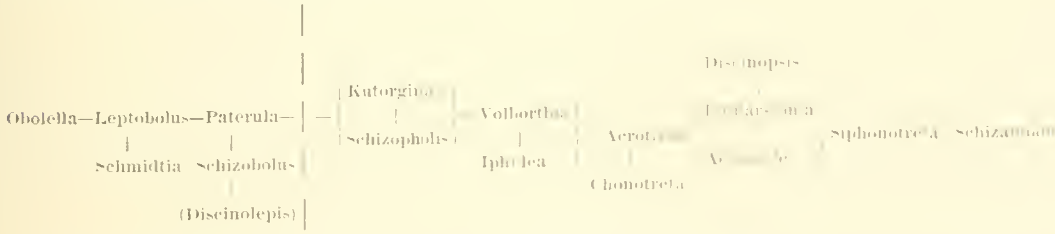


With the inception of a marginal pedicle-aperture taking the form of a slit in the substance of the shell, begins a series of variations which eventuate in Siphonotreta and Orbiculoidea. The association of this feature with the distinctive characters of the obolelloid stock has been observed only in the genera Schizobolus and Paterula, more definitely in the former. Its assumption appears to have been accompanied directly by an elevation of the posterior margin into a vertical, somewhat specialized area, suggesting the true cardinal area of the articulates. Thus, in the genera Kutorgina and its representative in the "Obolus beds" of the Salt-Range of India, Schizopholis, the subapical posterior slope, often incurved in Kutorgina, is divided for its entire height by a triangular opening. In Volborthia, Iphidea, and Acrotreta, essentially the same features are present, save that the pedicle-slit is represented by a ridge in Volborthia and Iphidea, and a furrow in Acrotreta, terminating in an aperture at the apex of the shell (Volborthia ?).

It has already been observed, that the explanation of these pedicle-characters and their apparent differences, may be found in the mode of growth of the shell. In Kutorgina and Schizopholis, the mantle of the shell or the pedicle itself has failed to secrete testaceous matter behind the aperture as growth advanced, thus

leaving, from youth to maturity, a triangular opening extending the entire width of the area. In Volborthia, Iphidea, and Acrotreta, the ridge or furrow indicates the modification of the surface made by the aperture. In Acrothele, the posterior slope is again less defined, and the progress of the foraminal scar not distinctly marked upon its surface. In these features the passage to Siphonotreta is imperceptible, while in Schizambon, the close ally of Siphonotreta in most respects, the position of the aperture is in front of the beak, and its advance with growth leaves between it and the apex a conspicuous furrow crossed by concentric lines of accretion. This we regard as an extreme of development in the character of the pedicle-passage, a point which is not passed by these shells.

The enclosure of the pedicle-slit, leaving only a circular perforation for the passage of the arm of attachment, appears to have been unaccompanied, as far as our evidence reaches, by any essential variations in internal conformation in the genera Volborthia, Iphidea, Chonotreta and Acrothele. In Acrotreta there is an elevation or mammiform swelling about the internal opening of the sipho, which necessarily gives the passage the character of a short tube. In Linnarssonia and Discinopsis this internal swelling becomes more extremely developed in lateral extension, while in Siphonotreta it is expressed in a greater longitudinal development, producing a well developed tube. The muscular impressions of this group of genera are so imperfectly understood that it is impossible to correlate them satisfactorily, but their biological relations, as far as expressed in the characters of the pedicle-passage, may be represented by the following diagram:



This scheme is not intended as an expression of the derivation or geological succession of these genera. Leptobolus and Schmidtia follow Obolella in the

faunas of the later Lower Silurian, associated with PATERULA, while SCHIZOBOLUS presents the only association of obolelloid characters known in Devonian faunas. KUTORGINA, SCHIZOPHOLIS, VOLBORTHIA, IPHIDEA, ACROTRETA, ACROTHELE, LINNARSSONIA and DISCINOPSIS belonged in a general sense to contemporaneous faunas of primordial age, while CHONOTRETA, SCHIZAMBON and SIPHONOTRETA are from the Lower Silurian.

We may have to seek the source whence these numerous closely allied primordial groups are derived, in some earlier comprehensive stock of which we now have no knowledge. The ages preceding the Silurian afforded abundant time for a tendency to variability to express itself; how far the apparent order of development will harmonize with the actual order of succession in the subordinate faunas of this time, must await demonstration.

The marginal pedicle-slit has followed still another line of development. The simple incision of the margin as in PATERULA, becomes in SCHIZOCRANIA a wide fissure extending to a subcentral beak, *i.e.*, for nearly the radius of the shell. Our observations upon the embryonic stages of ORBICULOIDEA have shown that the fissure, in early conditions of growth, is of similar character, its margins straight and divergent, but subsequently uniting to form the narrow pedicle-groove and tube. In TREMATIS, the margins of the slit are curved, but they never unite at the outer extremity, while in the genus ŒHLERTELLA of the Waverly group, the margins are more nearly straight, but the incision always open.

The apical accretion in the foramen of SCHIZOCRANIA, the structure of which has been alluded to in the preceding pages, finds its homologue in the allied genera. In TREMATIS it is less distinctly developed than elsewhere, but in ŒHLERTELLA its tripartite arrangement into a central groove for the passage of the pedicle, and two strong lateral walls enforcing the same effect, brings it into precise agreement with the structure of the groove in ORBICULOIDEA and SCHIZOTRETA, save that in the former the posterior walls of the slit have united at maturity.

Furthermore, from Schizocrania to Œhlertella and Schizotreta, there is a gradual increase in the degree of depression of this apical area. In the first genus this is very slight, the part often appearing to be in the plane of the valve; in Trematis the entire subapical area is depressed without any marked development of this feature, while in *Œhlertella pleurites* we find it to be exceedingly depressed, so that if the outer margins of the slit were united, a broad tubular passage to the interior would remain.

In general effect, there is a striking resemblance in the external appearance of the pedicle-area in Orbiculoidea and Schizotreta, and in Schizambon. This resemblance is, however, superficial, and can not be allowed to bring the extremes of development along different lines into a very close relationship.

In Schizambon (*S. fissus*), the pedicle-groove lying in front of the beak, is crossed by the interrupted growth-lines of the shell-surface, while in Orbiculoidea, the tripartite subdivision of the groove, never encroached upon by the concentric growth-lines, invariably maintains its posterior position.

In Discinisca, the same tripartite division of the pedicle-area gives evidence of relationship derived from Orbiculoidea, although the foramen has changed from an oblique to a vertical position; while, in Discina, the tubular character of the foramen is retained at the expense of the subdivision of the groove and has become inverted in its direction, so that the pedicle is protruded posteriorly instead of anteriorly or toward the apex as in Orbiculoidea. The evidence afforded by the developmental stages of Orbiculoidea demonstrates conclusively the primary taxonomic position of Schizocrania in this group.

Wherever there occurs a complete atrophy of the pedicle, it necessarily induces an important modification in the interior of the shell. In the genus Crania, where the whole function of the pedicle is effected by the substantial attachment of the lower valve, the opening and closing muscles are allowed greater freedom of action and their attachment to each of the two valves is of so similar a character that it is frequently a difficult matter to determine, from these features alone, whether a given valve is the upper or the lower. The arrangement of the muscular bands is essentially as in the discinoids, with

the pedicle-muscles and the modification produced by the presence of the pedicle-passage, abstracted.

In CRANIA and CRANIELLA, where the sedentary habit appears to be no more than a specific character, there is little variability in the nature of the muscular scars; in the genus PHOLIDOPS, however, the shells of which are invariably free, there is a concentration of the muscular scars at the middle of the valves, the strength of the impressions indicating that considerable power was required to keep the valves closed, with the muscles placed at this disadvantageous position.

SUPPLEMENT

TO THE

BRACHIOPODA INARTICULATA.

DESCRIPTIONS OF NEW SPECIES

REFERRED TO IN THE PRECEDING PAGES OR ON THE ACCOMPANYING PLATES.

Lingula compta, sp. nov.

PLATE I, FIG. 16.

Shell very narrow, with lateral margins nearly parallel for most of their length; the anterior margin transverse and the posterior less abruptly rounded. Shell-substance thin. Surface marked by fine concentric striæ.

The interior of the brachial (?) valve bears two strong lateral muscular ridges which meet in the median line at about one-third the length of the shell from the anterior margin. A narrow median furrow extends from just behind the center of the valve nearly to the anterior margin. Length of this valve, 9 mm., greatest width, 4.5 mm.

This species is allied to *L. densa*, Hall, but differs in its narrower form and thinner shell.

Hamilton group. *Tichenor's Gully, Canandaigua Lake, N. Y.*

Lingula scutella, sp. nov.

PLATE I, FIG. 30.

Shell broad, subquadrate; lateral margins parallel for a short distance, but soon rounding to the extremities, which have about equal curvature. Length to width as 2 to 3. Surface covered with more or less distinct concentric lines and wrinkles. The interior of the original valve, a cast of the interior,

shows a broad central elevation, corresponding to the muscular impressions, and converging ridges over the pallial region, representing the vascular sinuses. Fine radiating lines are also visible over the anterior region. Length of the valve, 12 mm., greatest width, 8 mm.

Chemung group. *Alleghany county, N. Y.*

LINGULA FLABELLULA, sp. nov.

PLATE I, FIGS. 33, 34.

SHELL large, subtriangular; lateral margins diverging from an acute apex, rounding broadly at about two-thirds the length of the shell, to the slightly transverse anterior margin. Length to greatest width as 6 to 7. Surface convex, sloping more abruptly to the sides than to the anterior margin; covered with low, rather faint and distant concentric lines or wrinkles. Shell-substance comparatively thick, showing fine radiating lines on the inner laminæ. Length of the largest specimen observed, 42 mm., greatest width, 36 mm.

Waverly group. *Sciotoville and Berea, Ohio.*

LINGULA PARACLETUS, sp. nov.

(See page 12, fig. 8.)

SHELL moderately large, broadly spatulate. Posterior margins diverging from an acute beak, rounding slowly to the sides of the shell where the curve is less: the interior margin is subcircular, rarely transverse. The greatest width of the shell is in front of the middle and the proportions of length to greatest width are as 2 to 1.3. Surface ornamented with distant, concentric wrinkles between which are exceedingly fine concentric striæ. On the interior the valves have a notably broad margin of contact. The internal cast sometimes shows this to be broadest at the middle of the anterior margin; faint radiating striæ are also observable on this cast. The muscular and vascular impressions of the interior are frequently well defined, as described on the page above cited. Length of the original specimen, 16 mm., width, 11 mm.

Waverly group. *Cuyahoga shales, Chardon, Ohio.*

LINGULA TÆNIOLA, nom. nov.

Lingula lamellata, HALL. Palæontology N. Y., vol. ii. p. 55, pl. xx, figs. 4 *a*, *b*, *c*

(See page 18.)

LINGULA LINGULATA, sp. nov.

PLATE IV K, FIG. 5.

SHELL elongate-subquadrate, having somewhat the form of *Lingula oblata*, Hall. Valves very slightly convex. Distinguished from other species by the peculiar deflection of the anterior portion of the shell considerably below the plane of the lateral margins.

Clinton group. *Near Hamilton, Ontario.*

LINGULOPS GRANTI, sp. nov.

PLATE IV K, FIGS. 14, 15.

SHELL small, linguloid in external aspect. Outline elliptical, subacuminate at the posterior extremity. External surface marked by faint, elevated, equidistant concentric lines. Margin of contact broad and conspicuous about the entire periphery. On the interior of the pedicle-valve the margin is broadest beneath the beak and slightly grooved on its posterior edge for the passage of the pedicle. The central and lateral muscular scars are elevated on a well developed platform, the ante-lateral margins of which meet each other at an acute angle. In the brachial valve the posterior margin is also broad and faintly grooved, the platform more conspicuously developed both in length, width and height than in the other valve, while the muscular scars have essentially the same arrangement. In neither valve do the specimens at hand afford evidence of the arched parietal impressions seen in the other species of the genus. Length of an average specimen, 5 mm., width, 3 mm.

This species differs from *L. Whitfieldi* and *L. Norwoodi*. not only in the absence of the parietal scars, but also in the development of the muscular area of the pedicle-valve into a distinct platform, and in the absence of the anterior longitudinal septum in the pedicle-valve.

Niagara group. *Hamilton, Ontario.*

Monomerella Greenii, sp. nov.

PLATE IV D, FIGS. 5 10.

Shell elongate-subovate. Valves comparatively shallow; shell-substance relatively thin. Surfaces of contact very broad, especially toward the posterior portion of the shell. Pedicle-valve with an erect but not high cardinal area, which is continuous with the broad margins. Umbonal cavities very short, rarely reaching to the hinge-line and sometimes scarcely more developed than in Dinobolus. Cardinal slope well defined and divided by a deep longitudinal groove. Cardinal buttress faint. Platform scarcely developed; the scars upon its surface usually faint, but the lateral impressions are sometimes sharply defined. Crescent and terminal scars generally distinct. Pallial sinuses usually discernible. Brachial valve with a low, rotund beak and transversely striated area. Umbonal cavity deep. The deep groove of the crescent is followed within by a sharply elevated ridge extending for the entire length of the cardinal line; terminal scars generally deeply impressed and apparently compound. Platform represented only by a median thickening of the muscular impressions, having the characteristic V-shaped outline and sometimes divisible into the component scars. From the anterior extremity of this muscular area two diverging ridges pass toward the anterior margin; these may be connected with the pallial sinuses.

This shell is readily distinguished from all other described species by the general tendency toward suppression of the platforms and muscular scars, the broad surface of contact, and the diverging anterior furrows of the brachial valve.

From the dolomites of the Niagara group, between *Cedarburgh* and *Grafton, Wisconsin.*

Monomerella Kingi, sp. nov.

PLATE IV D, FIGS. 1, 2.

Shell subcircular or longitudinally oval. Pedicle-valve probably with a low cardinal area, as far as may be judged by the size of the casts of the umbonal cavities, which are quite short, mammiform, not extending to the cardinal line. Cardinal buttress strong, produced as a septum nearly to the anterior edge of the platform. Platform well developed, broadly V-shaped; anterior wall vertical, not excavated; surface marked by strong impressions of mus-

cular attachments. Crescent distinct, terminal scars very prominent. Brachial valve with the umbonal region much thickened; the platform sharply V-shaped, its anterior wall being considerably excavated to form imperfect vaults; the whole elevation is situated somewhat further forward than the opposite valve. A faint longitudinal septum extends a short distance forward from the apex of the platform. Crown of the crescent faint; terminal scars as in the pedicle-valve.

From the magnesian limestone of the Niagara group, near *Cedarburgh, Wisconsin,* in association with *Dinobolus Conradi, Monomerella prisca* and *M. Greenii.*

MONOMERELLA ORTONI, sp. nov.

PLATE IV c, FIGS 14, 15.

PEDICLE-VALVE large, with a high cardinal area, which is gently incurved longitudinally and crossed by lamellose growth-lines, upon which the evidences of the deltidial ridges are extremely faint or altogether wanting. Umbonal cavities conspicuous, but much shorter than is usual in *M. prisca.* Cardinal slope large, triangular and divided by an axial furrow. Cardinal buttress broad at the base but not especially prominent. Platform apparent only at its anterior edge where it has a broad anterior slope. Crescent well defined beneath the hinge-line; terminal scars very prominent; central, lateral and anterior impressions discernible on the platform. Pallial sinuses very strong, the outer ramifications from which are distinctly seen.

Brachial valve unknown.

From the Niagara dolomitic limestone, at the *Rising Sun quarries, Wood county, Ohio.*

MONOMERELLA EGANI, sp. nov.

PLATE IV c, FIG 16.

BRACHIAL VALVE with an unusually high cardinal area, indicating a quite elevated beak. This area is strongly striated transversely, and bears two faint longitudinal depressions corresponding in position to the deltidial ridges of the pedicle-valve. It is continued laterally nearly to the middle of the margins. Crescent very narrow over the crown, lying close upon the cardinal line; at its turn forward it is developed into a deep, narrow, elongate

muscular scar, which is continued into a broader terminal impression. Platform sharply elevated at its anterior edge, sloping rather abruptly backward. Its surface bears the usual tripartite arrangement of the muscular scars. Anterior longitudinal septum distinct. From directly behind the crescent to the central muscular impressions, is a very broad, smooth, lunate slope, occupying the position of the simple umbonal cavity usual in this valve of MONOMERELLA, and presenting the appearance of an abnormal deposition or callosity.

Though represented by a single specimen only, this form shows features not elsewhere observed in the genus, viz., the great development of the cardinal area, the composite character of the muscular impressions terminating the crescent, and the broad posterior slope.

From the Niagara group, near *Grafton, Wisconsin.*

RHINOBOLUS DAVIDSONI, sp. nov.

PLATE IV B, FIGS. 10-12.

SHELL with a circular outline, except for the prominence of the beak. Pedicle-valve with a moderately high, acuminate cardinal area, upon which the central area, the deltidial ridges and areal borders have each about the same width. Cardinal slope short; crescent sharply defined; terminal scars distinct. Platform broadly V-shaped, sloping less abruptly backward than in *R. Galtensis.* Pallial sinuses faint. Brachial valve with marginal beak and inconspicuous area. Crescent more prominently developed than in the opposite valve, transverse over the crown as in DINOBOLUS; terminal scars large. Platform more sharply angulated than in the pedicle-valve and somewhat more elevated, bearing conspicuous lateral and anterior scars. Longitudinal septum not pronounced. Pallial sinuses quite distinct.

This species is based upon internal casts of opposite valves, which are in entire harmony with each other and are readily separated from *Dinobolus Conradi* and the various species of MONOMERELLA associated with them at the same locality. It is distinguished from the forms referred to *Rhinobolus Galtensis,* Billings, by its more circular outline, less elevated pedicle-umbo, inconspicuous brachial umbo, and broader, though less sharply elevated platform.

Niagara group. *Near Grafton, Wisconsin.*

Siphonotreta (?) Minnesotensis, sp. nov.

PLATE IV, FIGS. 37, 38

Shell subovate in outline. Pedicle-valve more convex than the brachial, slightly flattened along the median line, sloping with equal convexity toward the lateral and anterior margins. Foramen apical (?). Brachial valve depressed-convex, somewhat elevated about the umbo. Surface covered, in the umbonal region, with fine, anastomosing and gently undulating concentric lines, which, in the later portions of the shell, are finely granulose or serrated; at about one-third the length of the shell coarser varices of growth appear, between which the finer lines are retained. Surface covered with hollow spines of various sizes, which appear to have been most closely set over the umbonal region of the pedicle-valve. Here, where the growth-lines are absent, the spine-bases in the original specimen are large and all of about the same size and are disposed without order. Over the other portions of the shell the spines are set along the edges of the varices, small and large being indifferently mixed. The bases of the spines make annular swellings on the interior of the valves. The length of the original specimen is 15 mm., width, 12 mm.

Trenton limestone. *Minneapolis, Minnesota.*

Orbiculoidea (Schizotreta) ovalis, sp. nov.

PLATE IV E, FIGS. 4, 5.

Shell subelliptical in outline. Valves with apices situated a little behind the center. Lower valve with the apex erect or inclined slightly forward. External foraminal groove narrow, extending for about one-half the posterior radius of the valve. Surface about the foramen convex, but elsewhere slightly depressed in its slope from apex to margin. Upper valve more elevated than the lower, apex inclined backward, posterior slope gently concave. Surface marked by elevated nearly equidistant concentric striæ. Shell-substance thick, the inner laminæ showing fine radiating lines over the anterior region. Length of the original specimen, 8 mm., width, 6 mm., thickness through the apices of the conjoined valves, 3 mm.

Trenton limestone. *Middleville, N. Y.*

ORBICULOIDEA NUMULUS, sp. nov.

PLATE IV E, FIG. 14.

The original specimen is a lower valve, having a nearly circular outline. The apex is subcentral, elevated and directed anteriorly. The external groove of the foramen is moderately broad and extends one-half the length of the posterior radius. The posterior slope is convex while the anterior is depressed or slightly concave. Surface smooth about the apex, thence outward marked by a few distant, elevated, concentric lines or ridges, between which are numerous fine concentric lines. Length and width, 12 mm.

Lower Helderberg group (Waterlime). *Marshall, N. Y.*

ORBICULOIDEA HERZERI, sp. nov.

PLATE IV E, FIG. 19; AND PLATE IV F, FIGS. 9-13, 30.

SHELL subcircular in outline. Upper valve with an excentric apex, situated less than one-fourth the length of the shell from the posterior margin, and directed backward. Surface gently convex, sloping evenly forward from the apex, but abruptly depressed on the post-apical region. Lower valve with the apex much nearer the center; shell almost flat. Pedicle-aperture, in the primary stages of development, a triangular opening extending from the apex to the margin; this gradually closes with advancing growth, the external groove at maturity extending from one-half to two-thirds the length of the posterior radius of the valve. On the interior, the groove is frequently more or less enveloped by the development of testaceous deposits. Surface of both valves ornamented by crowded concentric lines and wrinkles. The internal surface of the lower valve sometimes shows fine radiating lines and faint vascular sinuses. Length and width of an adult individual, 14 mm.

Waverly group (Cuyahoga shales). *Berea, Baconsburg and elsewhere, Ohio.*

LINDSTRŒMELLA ASPIDIUM, gen. et sp. nov.

PLATE IV E, FIGS. 25-28.

This species is readily distinguished from *Orbiculoidea* (*Rœmerella*) *grandis*, its associate in the fauna of the Hamilton shales, and the only form with which

there is danger of confounding it, by the convex pedicle-valve, the distant, elevated, concentric surface-ridges, which have a peculiar undulation as they approach the margins of the foramen. The internal characters of the shell are at once distinctive. (See discussion of these features on page 134.) Length and width of a mature specimen, 50 mm.

Hamilton group. *Leonardsville, Hamilton, Darien and Canandaigua Lake, N. Y.*

SCHIZOCRANIA SCHUCHERTI, sp. nov.

PLATE IV G, FIGS. 31-33.

SHELL small, usually found unattached; marginal outline subovate. Surface of pedicle-valve flat or slightly concave; concentrically striated. Pedicle-aperture broad and sharply triangular. Brachial or upper valve strongly convex, often laterally compressed. Umbo full and rotund, incurved at the apex, which is almost, but not quite marginal. Surface covered by numerous simple, sharply elevated, uninterrupted striæ, frequently crossed by concentric wrinkles. On the interior of this valve only the strong posterior muscular impressions are distinctly shown.

Hudson River group. *Cincinnati, Ohio.*

SCHIZOCRANIA (?) HELDERBERGIA, sp. nov.

PLATE IV G, FIGS. 34, 35.

SHELL subcircular in outline. Upper valve convex: apex posterior and marginal. Surface covered with fine, closely crowded, elevated, radiating lines, which extend to the apex, and increase by intercalation. Lower valve flat and of less diameter than the upper. Apex subcentral, posterior. Foramen apparently a narrow triangular slit extending to the margin. A short median septum extends forward from the apex. External surface covered with low, crowded and rather faint concentric lines. On the interior, the surface bears a series of distant, deep but narrow radiating furrows, about twenty-five in number; these do not reach the apex, and increase in number toward the margin. Between them are very fine radiating lines. The animal was para-

sitic in its habit, attachment being considerably aided by the overlapping margin of the upper valve. Length and width of an average adult: upper valve, 9 mm., lower valve, 7.5 mm.

Lower Helderberg group. *Near Clarksville, N. Y.*

Crania agaricina, sp. nov.

PLATE IV H, FIG. 2.

Shell small. Apex posterior, slightly elevated. Surface covered by a few coarse, elevated, radiating lines, of which about twelve reach the apex. These increase by intercalation toward the margin, to about thirty. The edges of these ridges appear to be minutely granulose. Length of the original specimen (allowing for its incurvature upon the surface of attachment), 5 mm.

Lower Helderberg group. *Near Clarksville, N. Y.*

Crania pulchella, sp. nov.

PLATE IV H, FIG. 3.

Shell like that of *C. agaricina*, but larger and with much finer, more numerous radiating ribs. These are about sixty in number at the margin of the valve. Length of the original specimen, 8 mm.

Lower Helderberg group. *Near Clarksville, N. Y.*

Crania granosa, sp. nov.

PLATE IV H, FIGS. 19, 20.

The original specimen is an upper valve, quite irregular in its growth, with a nearly central beak and strong convexity. The surface is completely covered with closely set granules which are somewhat coarser toward the margins A few concentric wrinkles of growth are also visible. Diameter, 18 mm.

Hamilton group. *Centerfield, N. Y.*

Crania favincola, sp. nov.

PLATE IV H, FIG. 33.

Two interiors of the lower valve attached to a colony of *Favosites pirum* have very strongly developed muscular and vascular impressions. The posterior scars are large and their strongly elevated margins unite with the broad lateral border of the shell. The anterior scars are situated in front of the center and are partially enveloped by the great elevation of the anterior and median fulcra. The vascular sinuses are broad, slightly undulating grooves, extending from the median region to the anterior border. Length, 17 mm., width, 21 mm.

Hamilton group. *Crab Orchard, Kentucky.*

Craniella Ulrichi, sp. nov.

PLATE IV I, FIGS. 1, 2.

Shell moderately large. Outline normally circular. Apices subcentral, slightly posterior, inclined backwards. Upper valve with the posterior scars large and the adjustors well defined: anterior scars subdivided, the outer or posterior portion possibly representing the insertion of the brachial muscles. The vascular sinuses make a 3-shaped curve on the lateral portions of the valve, with the crest of the double arch toward the center: narrowing rapidly, becoming indistinct over the anterior region. Lower valve regularly convex, evidently unattached at maturity Anterior adductors very large, situated on a thickened posterior area Posterior adductor and adjustor scars very faint, lying just within the margin. The vascular sinuses are a series of low grooves extending forward in subparallel lines from the anterior and lateral margins of the central muscular area. External surface of the valves smooth or covered with concentric sublamellose growth-lines. Length of an upper valve, 11 mm., width, 12 mm.; diameter of a lower valve, 16 mm.

Trenton shale. *Minneapolis, Minnesota.*

Pholidops calceola, sp. nov.

PLATE IVI, FIG. 30.

Shell small. Outline subelliptical, the posterior margin being narrowed by the extension of the beak, which is long and acute, slightly elevated above the plane of the margin. External surface marked by concentric lamellose growth-lines, which extend about the posterior side of the beak. Muscular area central: posterior margin divided into a broad central and two lateral arches, from the latter the outline extending in a regular curve to the anterior margin. Adductor scars sharply defined. The dorsal (?) valve only is known. Length of the original specimen, 3.5 mm.

Corniferous limestone. *Falls of the Ohio.*

Pholidops patina, sp. nov.

PLATE IVI, FIGS. 27-29.

Shell comparatively large; outline elongate-ovate or elliptical. Length to width as 3 to 4. Apex posterior. Surface covered with lamellose concentric growth-lines, which are crossed by fine, interrupted radiating striæ. The interior of the ventral (?) valve has the anterior and posterior adductors well defined, the latter being lobate. The median scars are well developed and the parietal impression acutely angled at the center. In the opposite valve the anterior edges of the muscular area are sharply elevated, both pairs of adductor scars prominent, and the parietal scar extended posteriorly.

Corniferous limestone; from boulders of decomposed chert. *De Cewville, Ontario.*

SUPPLEMENTARY NOTE ON THE GENUS KUTORGINA.

Some interesting observations which bear upon the phylogenetic relations of this obscure genus, have recently been made by Mr. G. F. MATTHEW, in a paper entitled "Canadian Organisms in Acadia," published in the Transactions of the Royal Society of Canada, article xii, p. 135. 1890. The author has described and illustrated the development of his species. *Obolus pulcher* (see Plate IV K, fig. 22), and though it may not be proven that this form can be safely included within the genus OBOLUS, it is distinctly oboloid. These observations are based upon adult shells which retain evidence of differential stages of shell-growth with sufficient distinctness to allow of the following subdivision:

"(1) *Embryonic.* Formation of the embryonic shell.

"(2) *Larval.* Lengthening of the hinge-line and acquisition of mantle margins.

"(3) *Adolescent.* Fixation of the hinge-line, otherwise as the last. except the radular ornament becomes irregular.

"(4) *Adult.* Absence of radular ornamentation on the valve and great expanse of the mantle margin."

In the earliest stages represented (plate viii, figs. 1 *a–e*, brachial valve, figs. 2 *a–d*, pedicle-valve), the hinge is straight and long, making the greatest diameter of the shell, the umbo of the pedicle-valve is elevated and the cardinal area erect and with a triangular pedicle-aperture. The resemblance to KUTORGINA in the growth-stage is at once striking, and it may serve to indicate the subordinate value of this genus in its relation to the oboloid stock.

II.

BRACHIOPODA ARTICULATA.

Valves articulated; intestine terminating in a blind sac; shell-substance essentially calcareous.*

So far as our knowledge of the fossil species extends, there are very few of the forms included in this division to which the above definition does not apply. Several genera show very considerable modification of the articulating apparatus, but with rare exceptions these modifications in each group appear to be progressive, extending along certain lines of development and finally acquiring an extravagant manifestation, which may terminate abruptly or result in the degeneration and obsolescence of some of the parts.

In the group of fossils which are currently referred to ORTHIS there are several well marked subdivisions, which are in some degree coincident with geological succession, and the later of these show a tendency to the extravagant development of certain characteristic features, while the genus ENTELETES, which can be affiliated only with ORTHIS, presents a most remarkable exaggeration in the development of certain parts.

On the other hand, the articulating apparatus in STROPHODONTA, PRODUCTUS, etc., is by some authors regarded as being in a degenerative condition, and on this account they would place these genera near the base of the articulate division, though the type of structure exhibited by them is much more highly modified than in ORTHIS and its immediate allies in the older rocks.

The mode of articulation in PRODUCTUS appears to have come legitimately from the progress and development of some portions of the articulating appa-

*The definition of the BRACHIOPODA INARTICULATA and BRACHIOPODA ARTICULATA is derived from the structure of analogous living forms.

ratus on the one hand, and the obsolescence of other characters, which appear in the earlier forms of strophomenoid shells and have become modified in their progress through the chonetids. This may in one aspect be regarded as a degeneration, while in another it is apparently a development or progress, and affords no sufficient reason for beginning at the end of a series and going backward.

Of the various designations which have been proposed with a signification equivalent to Professor HUXLEY'S term* for this subdivision of the BRACHIOPODA, are ARTHROPOMATA, OWEN,† CLISTENTERATA, KING;‡ while BRONN§ made use of the two names TESTICARDINES and APYGIA.

No attempt is here made toward any grouping of the genera into the numerous families or sub-families which have been proposed by different authors. In this division, as in the BRACHIOPODA INARTICULATA, our knowledge has so greatly increased in the past years that such a classification if attempted must be arbitrary and procrustean, and would only be embarrassing to the student without any corresponding benefit. The interrelations of these genera will be better understood from the discussions under each one, and will be briefly summarized in a concluding chapter.

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1868. *Orthis*, MEEK. Trans. Chicago Acad. Sciences, vol. i, pp. 88–90.
1868. *Orthis*, McCHESNEY. Trans. Chicago Acad. Sciences, vol. i, p. 29.
1869. *Orthis*, SAFFORD. Rept. Geology Tennessee, pp. 286, 328, 533.
1870. *Orthis*, A. WINCHELL. Proc. Amer. Philosophical Society, vol. xii, p. 251.
1870. *Orthis*, MEEK. Proc. Amer. Philosophical Society, vol. xii, p. 425.
1872. *Orthis*, MEEK. Final Rept. Palæont. Eastern Nebraska, p. 173.
1872. *Orthis*, MEEK. Prelim. Rept. U. S. Geological Survey Montana, p. 295.
1872. *Orthis*, MEEK. American Journal of Science, vol. iv, p. 281.
1872. *Orthis*, HALL AND WHITFIELD. Twenty-fourth Ann. Rept. N. Y. State Mus. Nat. Hist., p. 181.
1873. *Orthis* (*Platystrophia*), MEEK. Geological Survey of Ohio; Palæontology, vol. i, pp. 92, 114.
1873. *Orthis*, MEEK. Sixth Ann. Rept. U. S. Geological Survey Territories, p. 464.
1873. *Orthis*, MEEK AND WORTHEN. Geological Survey Illinois, vol. v, p. 571.
1874. *Orthis*, DERBY. Bull. Cornell University, vol. i, No. 2, pp. 26, 29, 63.
1874. *Orthis*, BILLINGS. Palæozoic Fossils, vol. ii, pp. 32–35.
1874. *Orthis* (*Platystrophia*), JAMES. Cincinnati Quarterly Journal of Science, vol. i, p. 19.
1874. *Orthis*, RATHBUN. Bull. Buffalo Soc. Nat. Hist., vol. i, p. 247.
1874. *Orthis*, NICHOLSON AND HINDE. Canadian Journal, new series, vol. xiv, pp. 144, 158.
1875. *Orthis*, MILLER. Cincinnati Quarterly Journal of Science, vol. ii, pp. 19–40.
1875. *Orthis*, WHITE. Wheeler's Survey 100th Meridian, pp. 55, 70, 74, 125.
1875. *Orthis*, NICHOLSON. Rept. Palæontology, Province Ontario, pp. 16, 47.
1875. *Orthis*, HALL AND WHITFIELD. Geological Survey Ohio; Palæontology, vol. ii, pp. 75–77.
1877. *Orthis*, MEEK. U. S. Geological Expl. Fortieth Parallel, vol. iv, p. 63.
1877. *Orthis*, HALL AND WHITFIELD. U. S Geological Expl. Fortieth Parallel, vol. iv, pp. 232, 265.
1878. *Orthis*, CALVIN. Bull. U. S. Geological Surv. Territories, vol. iv, No. 3, p. 728.
1879. *Orthis*, RATHBUN. Proc. Boston Society Natural History, p. 23.
1879. *Orthis*, JAMES. Palæontologist, No. 4, pp. 26, 31.
1879. *Orthis*, ULRICH. Journ. Cincinnati Society Natural History, vol. ii, p. 15.
1879. *Orthis*, HALL. Twenty-eighth Ann. Rept. N. Y. State Mus. Nat. Hist., p. 149.
1880. *Orthis*, N. H. WINCHELL. Eighth Ann. Rept. Geol. and Natural History Survey of Minnesota, pp. 63–68.
1880. *Orthis*, WHITE. Second Ann. Rept. Bureau Stat. and Geology Indiana, pp. 484–486.
1881. *Orthis*, WHITE. Tenth Report Indiana State Geologist, pp. 116, 133.
1881. *Orthis*, WHITE. Wheeler's Survey 100th Meridian. Appendix, p. xxiii.
1881. *Orthis*, N. H. WINCHELL. Ninth Ann. Rept. Geol. Surv. Minnesota, p. 115.
1881. *Orthis*, MILLER. Journ. Cincinnati Society Natural History, vol. iv, pp. 8, 313.
1882. *Orthis*, MILLER. Journ. Cincinnati Society of Natural History, vol. v, pp. 16, 40.
1882. *Orthis*, WHITFIELD. Geology of Wisconsin, vol. iv, pt. 3, Palæontology, pp. 258, 260, 320, 326.
1882. *Orthis*, HALL. Eleventh Ann. Rept. State Geologist Indiana, pp. 268, 285, 286.
1882. *Orthis*, WHITFIELD. Bull. American Museum Natural History, vol. i, No. 3, p. 45.
1883. *Orthis*, HALL. Thirty-sixth Ann. Rept. N. Y. State Mus. Nat. Hist., pp. 73–75.
1883. *Orthis*, HALL. Twelfth Ann. Rept. State Geologist Indiana, p. 324.
1883. *Orthis*, WHITE. Twelfth Ann. Rept. U. S. Geol. Survey Territories, p. 164.
1883. *Orthis*, HALL. Ann. Rept. N. Y. State Geologist for 1882, plates 34–37.
1883. *Orthis*, HALL. Transactions Albany Institute, vol. x, p. 70.
1884. *Orthis*, WHITE. Thirteenth Ann. Rept. State Geologist Indiana, p. 129.
1884. *Orthis*, WALCOTT. Palæontology of the Eureka District, pp. 22, 72, 74, 114, 115.
1885. *Orthis*, N. H. WINCHELL. Fourteenth Ann. Rept. Geol. and Nat. Hist. Surv. Minnesota, pp. 317, 318.
1885. *Orthis*, FOERSTE. Bull. Denison University, vol. i, pp. 80–87.

1886. *Orthis*, Walcott. Bull. No. 30, U. S. Geological Survey, p. 119.
1886. *Orthis*, Whitfield. Bull. American Museum Natural History, vol. i, No. 8, p. 300.
1887 *Orthis*, *Platystrophia*, Shaler. Mem. Kentucky Geological Survey, vol. i, pt. 3, pp. 18, 19, 22.
1887. *Orthis*, Walcott. American Journal of Science, vol. xxxiv, p. 190.
1888. *Orthis*, Herrick. Bull. Denison University, vol. iii, p. 38; vol. iv, p. 14.
1888. *Orthis*, Ringueberg. Proc. Acad. Nat. Sci. Phila., p. 134.
1889. *Orthis*, Whitfield. Bull. American Museum Natural History, vol. ii, No. 2, p. 43.
1889. *Orthis*, Nettelroth. Kentucky Fossil Shells, pp. 32-45.
1889. *Orthis*, Beecher and Clarke. Mem. N. Y. State Museum, vol. i, No. 1, pp. 14-17.
1889. *Orthis*, Simpson. Trans. American Philosophical Society, p. 137.
1890. *Orthis*, Foerste. Proc. Boston Soc. Nat. Hist., vol. xxiv, p. 308.

Diagnosis. Shell subcircular or subquadrate in outline. Valves more or less convex, the smaller or brachial valve being sometimes nearly flat or slightly concave. Hinge-line straight and equal to, or shorter than the greatest width of the shell. Cardinal area well developed on each valve and divided by an open triangular delthyrium.* Beaks more or less incurved. Surface covered by radiating costæ, with faint evidence of median fold and sinus.

In the interior of the pedicle-valve the large hinge-teeth are supported by dental plates which are more or less conspicuously developed, frequently resting upon the bottom of the valve The bases of these are continued as a low elevation about the muscular area. The subdivisions of this muscular impression are rarely distinct: it is divided longitudinally by an inconspicuous median ridge and the larger expansions on each side were probably occupied by the diductor muscles; within these and lying close against the median ridge are the adductors, while the pedicle muscles covered the posterior deltidial portion of this area.

In the interior of the brachial valve the apex of the deltidial cavity bears

*The term *deltidium* was proposed by von Buch for the triangular *plate* which, in many articulate genera, covers more or less completely the space between the outer margins of the dental ridges. This plate he describes as composed of two pieces which may either completely surround the foramen (*deltidium amplectens*), bound it on its lower side (*deltidium sectans*), or the parts may be separated for their entire length by the foramen (*deltidium discretum*). These component parts of the deltidium take their origin from the margins of the triangular cavity beneath the beak, but in some genera, particularly in Strophomena, Spirifer and their allies, there is still another form of shelly plate which grows from the apex downward, and to this the term *pseudodeltidium* was applied by Bronn. Among recent writers there has been considerable laxity in the use of these terms and it is very doubtful if they can be applied with precision. In the discussion of mature characters with which this work has principally to deal, the term *deltidium* is applied to the outer plate covering the deltoid fissure, irrespective of valves, and for this so-called "deltidial fissure," the term *delthyrium* (δέλτα and θυρίον) is suggested.

a more or less developed cardinal process or callosity, which, in the typical group, is elongate and usually simple at its termination. The dental sockets are deep and their inner walls support short divergent crura. The muscular impression is more or less distinctly quadruple, being divided longitudinally by a median ridge extending forward from the cardinal process, and transversely by fainter ridges. This quadruple scar marks the place of attachment of the adductor muscle.

Ramified vascular markings are often retained over the pallial area, the principal trunks diverging from the median region and nearly following the curve of the anterior margin of the shell. Between these and the adductor impressions the markings of the ovarian areas are sometimes visible.

Shell-structure fibrous and impunctate in the typical group.

Observations. The foregoing diagnosis is based upon a stricter interpretation of the generic characters than usually adopted by authors. The very great number of species which are currently referred to the genus, and the constant reference of new species of varied character to the same generic term imply a want of homogeneity in the group, while in the present state of knowledge it seems possible to indicate certain differential characters which will serve as a basis for subsidiary classification. Differences in external contour of the species are often extreme. The mind unwillingly associates the transversely elongated, Spirifer-like forms of *Orthis biforata* with the round, lenticular shells of *Orthis testudinaria*, the cordate *Orthis biloba*, or the inflated and resupinate *Orthis Macfarlanii.* In the muscular markings also there are some extreme variations; *e. g.*, *Orthis calligramma*, with the scars obscure and confined to the umbonal region, *Orthis musculosa*, having them very deep and of immense size, covering almost the whole of the inner surface of the pedicle-valve. The cardinal process varies in its form, size and degree of lobation; the dental lamellæ are more or less prominently developed, and of still greater importance is the fact that in its minute anatomy the shell is sometimes compactly prismatic and impunctate, sometimes of looser texture and the inner laminæ abundantly supplied with vertical tubules.

The genus ORTHIS was thus defined by DALMAN:*

"Testa inæquivalvis, æquilatera: valva minori subplana, majori convexa.

"Margo cardinalis rectilineus, latus, foramine deltoideo sub nate valvæ majoris."

Nine species were cited as examples of the genus, and in the following order: *O.? pecten*, *O. striatella*, *O. zonata*, *O. callactis*, *O. calligramma*, *O. testudinaria*, *O. basalis*, *O. elegantula*, *O. demissa*.

Mr. DAVIDSON quite properly takes exception† to the use of the first of these as the type of the genus since the author himself‡ expressed a doubt of its validity by the use of the interrogation point, and the shell proves to be a strophomenoid (STROPHONELLA).§ The second species, *O. striatella*, was taken by FISCHER DE WALDHEIM, in 1837‖ as the type of his genus CHONETES, and with entire propriety, as its generic character was also placed in doubt by DALMAN in his description of the species.

Orthis zonata, the third species, was referred by DE VERNEUIL¶ to *Orthisina adscendens*, Pander, but the figure of this species given by DALMAN indicates that it had an open delthyrium, though it is quite possible that the deltidium had been destroyed in the original specimen, as frequently occurs in such fossils. Little is known of this species, but under the now accepted rules of priority it should be taken as the typical form of the genus. This procedure, however, would be impracticable at the present time, and would create a deplorable disturbance in nomenclature without giving any beneficial result. The fourth species in the list, *O. callactis*, and the fifth, *O. calligramma*, are well known and very closely allied to each other. They are characteristic members of Silurian faunas, ranging from the Llandeilo to the Wenlock formations,** and represented in America by *O. tricenaria* and *O. disparilis*, Conrad, of the

* Uppställning och Beskrifning af de i Sverige funne Terebratuliter, *loc. cit.* pp. 96, 97; pl i, figs. 5 *a*, *b*, 6 *a–d*; pl. ii, figs. 1 *a–e*, 2, 3 *a–d*, 4 *a–e*, 5 *a–e*, 6 *a–g*, 7 *a–d*.

† Introduction to British Fossil Brachiopoda, p. 103, 1853, and General Summary, p. 377. 1884.

‡ DALMAN, *op cit*, p. 110.

§ See DAVIDSON, British Silurian Brachiopoda, p. 304. 1871.

‖ Oryct. Gouvern. de Moscou, part ii, p. 134.

¶ Géologie de la Russie d'Europe et des Montagnes de l'Oural, p. 203. 1845.

** British Silurian Brachiopoda, p. 245.

Trenton, and *O. Davidsoni*, de Verneuil (*O. calligramma*, var., according to Davidson*), of the Niagara.

Mr. DAVIDSON was disposed to regard the Swedish specimens of *O. callactis* as showing but varietal differences from *O. calligramma*, and his use of these two terms, the former subordinate to the latter, should strictly be reversed. *Orthis callactis* may, therefore, properly be taken as the typical form of the genus in its restricted construction, and upon the diagnosis above given it will be necessary to exclude the remainder of DALMAN'S species, with the exception of *O. demissa*, as it will be shown that *O. testudinaria*, *O. basalis* and *O. elegantula* belong to a distinct type of structure.†

ORTHIS, DALMAN, as restricted.

I. Group of ORTHIS CALLACTIS, Dalman. 1828.

PLATE V, FIGS. 1-17, 37-41.

1828. *Orthis*, DALMAN. Kongl. Vet. Acad. Handl., pp. 93, 96.
1830. *Orthambonites*, PANDER. Beitr. zur geognos. des russisch. Reiches, p. 80, pl. iii, fig. 7; pl. xxviii, fig. 18.
1839. *Orthis*, SOWERBY. Murchison's Silurian Syst., p. 639, pl. xxi, fig. 8.
1843. *Orthis*, HALL. Geology N. Y.; Rept. Second Dist., p. 105, fig. 5.
1843. *Orthis*, CONRAD. Proc. Acad. Nat. Sci., Philadelphia, vol. i, p. 333.
1844. *Orthis*, OWEN. Geol. Expl. Iowa, Wisconsin and Illinois, pl. xv, fig. 11.
1847. *Orthis*, HALL. Palæontology N. Y., vol. i, p. 20, pl. iv *bis*, fig. 4; pp. 119, 121, pl. 32.
1852. *Orthis*, HALL. Palæontology of N. Y., vol. ii, pp. 254, 255, pl. lii, figs. 6, 7.
1856. *Orthis*, BILLINGS. Canadian Nat. and Geol., vol. i, p. 136, pl. ii, fig. 6.
1859. *Orthis*, BILLINGS. Canadian Nat. and Geol., vol. iv, p. 440, fig. 20.
1859. *Orthis*, SALTER. Canadian Organic Remains, Decade i, p. 39, pl. ix, figs. 1-4.
1862. *Orthis*, BILLINGS. Palæozoic Fossils, vol. i, p. 77, fig. 70; p. 78, fig. 71; p. 81, fig. 73.
1862. *Orthis*, HALL. Geology of Wisconsin, vol. i, p. 42, figs. 8-11; p. 135.
1863. *Orthis*, BILLINGS. Geology of Canada, p. 130, fig. 60; p. 167, fig. 151; p. 231, fig. 245; p. 312, fig. 318.
1865. *Orthis*, SHALER. Bulletin No. 4, Mus. Comparative Zool., p. 66.
1875. *Orthis*, NICHOLSON. Palæontology Province Ontario, p. 47, fig. 21.
1875. *Orthis*, WHITE. Geogr. and Geol. Expl. west 100th Merid., p. 72, pl. iv., fig. 10.
1883. *Orthis*, HALL. Rept. N. Y. State Geologist for 1882, pl. xxxiv, figs. 35-38, 41, 42 and pl. xxxv, figs. 1-8.

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* British Silurian Brachiopoda, p. 244.

† DALMAN'S paper of 1828 has become so rare as to be beyond the reach of most American students. We have, therefore, reproduced by photo-engraving the first two plates of this work with the precise form and arrangement of the original, and they will be found inserted at the end of these discussions, and preceding the lithographic plates. These plates are Tab. I and II of the Kong. Vetenskaps Academiens Handlingar för ar 1827, and bear all of the author's figures of the species of ORTHIS as well as those of his genus LEPTÆNA.

1884. *Orthis*, Walcott. Palæontology Eureka Dist., p. 74, pl. xi, fig. 4.
1885. *Orthis*, Foerste. Bull. Denison Univ., vol. i, p. 82, pl. xiii, fig. 12.
1889. *Orthis*, Nettelroth. Kentucky Fossil Shells, p. 38, pl. xxxiv, fig. 30.
1890. *Orthis*, Foerste. Proc. Boston Soc. Nat. Hist., vol. xxiv, p. 308, pl. vi, figs. 4, 5.

The distinguishing features of these shells are the plano-convex contour; the strong, sharp and comparatively few costæ, rarely, if ever, bifurcating; the elevated and somewhat incurved cardinal area on the pedicle-valve; the relatively slight development of the dental lamellæ, which do not extend the entire length of the umbonal cavity. The cardinal process on the brachial valve is an elongate, vertical plate, extending from the apex the whole length of the delthyrium, thus longitudinally dividing the deep deltidial cavity. It is usually simple, both on the outer edge and at its distal extremity.

In this group of orthids, more frequently than elsewhere, we find a character rarely developed in any stage of growth, viz.: the existence of a transverse apical plate in the delthyrium of the pedicle-valve. This is probably homologous to the apical plate of the Spirifers, but is wholly distinct in origin from the covering of the delthyrium. The greatest development attained by this feature, in any of the numerous species of Orthis studied, is to be found in *O. tricenaria* of the Trenton and Hudson faunas; it has also been observed in *O. calligramma*, var. *Davidsoni*, although it does not appear in any of the figures of this species and its varieties given by Mr. Davidson, nor is any mention made of it in his descriptions.* Its appearance in this genus, and especially in the typical species of the genus, is interesting, but it can not be embraced in the diagnostic characters since its presence appears to be largely of a specific value, and the degree of its development dependent upon the stage of growth.

The muscular scar of the pedicle-valve of *O. calligramma* is a subelliptical area scarcely longer than the cardinal face, faintly impressed, and its components rarely distinguishable.

The structure of the shell is compactly fibrous and impunctate. Specimens of *Orthis calligramma*, var. *Davidsoni*, from Gotland, show openings of oblique tubules on the external surface, always situated upon the keels of the costæ. These are sparse and irregularly scattered, but of similar nature to those seen in the

* See British Silurian Brachiopoda, p. 240, pl. xxxv, figs. 1-19.

impunctate species, *O. subquadrata*, and the punctate species, *O. subæquata*, *O. Michelini*. *O. resupinata*, and their allies.

The *Orthis? laurentina*, Billings, from the Anticosti group, is an interesting species, similar in surface, contour and interior to *Orthis calligramma*, but in the pedicle-valve the delthyrium is persistently covered with a convex plate without trace of an opening, and in the brachial valve the deltidium is more or less complete.

PLECTORTHIS

(nom. propos).

II. Group of ORTHIS PLICATELLA, Hall.

PLATE V, FIGS. 18-26.

1847. *Orthis*, HALL. Palæontology N. Y., vol. i, pp. 120–122, pl. xxxii, figs. 6, 7, 9.
1861. *Orthis*, MCCHESNEY. Description New Palæozoic Fossils, p. 77.
1861. *Orthis*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 121.
1861. *Orthis*, HALL. Fourteenth Rept. N. Y. State Cab. Nat. Hist., p. 90.
1862. *Orthis*, cf. *Trematospira*, HALL. Fifteenth Rept. N. Y. State Cab. Nat. Hist., pl. ii, figs. 6–8.
1863. *Orthis*, BILLINGS. Geology of Canada, p. 165, fig. 145.
1868. *Orthis*, MCCHESNEY. Transactions Chicago Acad. Sci., vol. i, p. 29, pl. ix. fig. 3.
1872. *Orthis*, MEEK. American Journal Science, vol. iv, p. 281.
1872. *Orthis*, MEEK. Palæontology of Ohio, vol. i, pp. 106–109, pl. viii, figs. 6–8.
? 1873. *Orthis*, MEEK. Palæontology of Ohio, vol. i, p. 105, pl. viii, fig. 9.
? 1874. *Orthis*, BILLINGS. Palæozoic Fossils, vol. ii, p. 34, pl. 3, fig. 3
1875. *Orthis*, HALL and WHITFIELD. Palæontology of Ohio, vol. ii (? p. 76, pl. i, fig. 20); p. 77, pl. i, figs. 21, 22.
1875. *Orthis*, MILLER. Cincinnati Quart. Jour. Sci., vol. ii, pp. 30–33.
1879. *Orthis*, ULRICH. Journal Cincinnati Soc. Nat. Hist., vol. ii, p. 15, pl. vii, fig. 11.
1881. *Orthis*, N. H. WINCHELL. Ninth Ann. Rept. Geol. and Nat. Hist. Surv. Minnesota, p. 115.
1884. *Orthis*, WALCOTT. Palæontology Eureka Dist., p. 73, pl. xi, fig. 5.

This is a persistent form, which in American faunas, so far as known, is limited to the Trenton and Hudson River formations. While it retains the strong external ribs of the typical ORTHIS, these are not invariably simple (*O. fissicosta*, Hall; *O. triplicatella*, Meek; *O. æquivalvis*, Hall, not Davidson; *O. Jamesi*, Hall); the cardinal area of the pedicle-valve is comparatively low and the valves are subequally convex. In the interior the character of the muscular scars, dental lamellæ and cardinal process is essentially the same as in Group I, and the minute structure of the shell appears to be in precise agreement with that of *O. calligramma*, though no evidence of tubulose costæ has been observed. In

Orthis Jamesi, which is placed in this association, there is occasionally a deviation toward the resupinate contour exemplified in the Groups IV and V.

DINORTHIS

(nom. propos.)

III. Group of Orthis pectinella (Conrad, MS.), Emmons.

PLATE V, FIGS. 27-36.

1842. *Orthis*, Emmons. Geology N. Y.; Rept. Second Dist., p. 394, fig. 2.
1847. *Orthis*, Hall. Palæontology of N. Y.; vol. i, pp. 123, 124, pl. xxxii, figs. 10, 11.
1856. *Orthis*, Billings. Canadian Nat. and Geol., vol. i, p. 136, pl. ii, fig. 6, and p. 205, fig. 5.
1858. *Orthis*, Rogers. Geology of Pennsylvania, vol. ii, p. 818, fig. 602.
1863. *Orthis*, Billings. Geology of Canada, p. 165, fig. 147.
1881. *Orthis*, N. H. Winchell. Ninth Annual Rept. Geol. and Nat. Hist. Surv. Minnesota, p. 117.
1882. *Orthis*, Whitfield. Geology of Wisconsin, vol. iv, p. 259, pl. xii, fig. 8.
1883. *Orthis*, Hall. Rept. N. Y. State Geol. for 1882, pl. xxxiv, figs. 39, 40.

This group of shells, in its most characteristic examples, presents a reversal of the relative convexity of the valves as seen in *Orthis calligramma*. The pedicle-valve, elevated at the umbo, becomes gradually depressed as growth advances, and in the mature condition is flat or gently concave over the pallial region. The brachial valve, on the other hand, is eminently convex. The surface is marked by strong, simple, rarely bifurcating costæ, as in *O. calligramma*. The cardinal area of the pedicle-valve is well developed but not greatly elevated. In the interior the dental lamellæ are prominently developed and are extended around a subquadrate muscular area, the strength of which apparently depends upon the age and thickness of the shell. The three pairs of impressions may often be distinguished; the elongate adductors occupying a central position and separated by a faint median ridge, the diductors forming large ante-lateral expansions enclosing the adductors; the adjustors lie outside and behind these. Occasionally, in *Orthis pectinella*, there is again seen the gradual closing of the delthyrium of the pedicle-valve by an apical callosity, but it is never carried as far as in the forms mentioned in the group of *Orthis callactis*, and, so far as observed, its existence is confined to the species cited. In the brachial or more convex valve the area is narrower, the crural plates stronger than in the preceding groups, and the cardinal process, instead of being a simple linear ridge lying in the bottom of the deltidial cavity,

is an erect apophysis, broadened and frequently bilobed on its summit and posterior face.

The shell-structure, like that of *Orthis callactis* and *O. plicatella*, is compactly fibrous, and in all the species examined, impunctate. No evidence of tubulose plications has been seen.

In American faunas this is a small section limited to a few Silurian species, such as *O. pectinella*, Conrad, and *O. Sweeneyi*, N. H. Winchell, from the Trenton limestone, and it is closely allied in some general respects to the typical members of Group V, but the minor differences will be found of permanent value.

The other impunctate reversed shells may be separated into two groups, first,—

PLÆSIOMYS

(nom. propos).

IV. Group of ORTHIS SUBQUADRATA, Hall.

PLATE VA, FIGS. 14-21, 28-34.

1843. *Strophomena*, CONRAD. Proc. Acad. Nat. Sci., Phila., vol. i, p. 332.
1847. *Orthis, Leptæna*, HALL. Palæontology of N. Y., vol. i, pp. 113, 126, pl. xxxii a, fig. 1; pl. xxxi b, figs. 5, 6.
1858. *Orthis*, SALTER. Mem. Geol. Surv. Great Britain, vol. ii, p. 373, pl. xxvii, figs. 3, 4.
1859. *Orthis*, BILLINGS. Canadian Nat. and Geol., vol. iv, p. 438, fig. 15.
1859. *Strophomena*, HALL. Twelfth Rept. N. Y. State Cab. Nat. Hist., p. 70.
1861. *Orthis*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 120.
1861. *Orthis*, MCCHESNEY. Descriptions New Palæozoic Fossils, p. 78.
1862. *Orthis*, HALL. Geology of Wisconsin, p. 54, fig. 1, 2.
1862. *Orthis, Strophomena*, BILLINGS. Palæozoic Fossils, vol. i, p. 130, fig. 108; p. 133, fig. 110; p. 135, fig. 111, and p. 136, figs. 112, 113.
1863. *Orthis*, BILLINGS. Geology of Canada, p. 129, fig. 54; p. 165, fig. 146, and p. 312, fig. 319.
1873. *Orthis*, MEEK. Palæontology of Ohio, vol. i, pp. 92, 94, pl. ix, fig. 2, and pl. xi, fig. 7.
1875. *Orthis*, MILLER. Cincinnati Quart. Jour. Sci., vol. ii, pp. 37, 38.
1880. *Orthis*, WHITE. Second Ann. Rept. Indiana Bureau Statistics and Geol., p. 484, pl. i, figs. 3-5.
1881. *Orthis*, WHITE. Tenth Rept. Indiana State Geol., p. 116, pl. i, figs. 3-5.
1883. *Orthis*, HALL. Rept. N. Y. State Geol. for 1882, pl. xxxiv, figs. 28, 29.
1887. *Orthis*, SHALER. Mem. Kentucky Geol. Surv., pp. 19, 22, pls. vi, vii.

It may be difficult to point out external characters in which the shells of this section differ from those of Group V. In *Orthis subquadrata* there is the same general expression in contour and surface, but the reversal in the convexity of the valves, and the retrorsion of the umbo of the pedicle-valve is

not so great as in species of that section. These features, however, are regarded as of less importance, but on the basis of internal structure may be included such forms as *Orthis porcata*, McCoy, in which the brachial valve is very convex, and *Orthis retrorsa*, Salter, where the retrorsion of the beak is carried to a greater extreme than in any other species of ORTHIS.

In the interior of the pedicle-valve there is a large quadrate muscular scar with a tendency to bilobation by the lateral extension of the diductor impressions. The subdivision of this area into separate scars is frequently very distinct. In the brachial valve the cardinal process is thickened and erect at its posterior extremity, being distinctly crenulate on the summit and posterior face. The surface striæ are tubulose and the shell-structure fibrous-impunctate.

While the muscular scars in this group are somewhat similar to those of Group III, and the external features like those of Group V, the combination here described is persistent, though represented by few species. To those above mentioned may be added *O. reversa*, Salter, from the Lower Llandovery, and probably several others from the Silurian of Great Britain.

The type appears to be limited to the faunas of the Lower Silurian.

There is a small group of early species, agreeing with *Orthis subquadrata* in the reversion of the valves and the form of the muscular scars and cardinal process, but characterized by the existence of a more or less completely developed convex deltidium. To this group belong the *Strophomena deflecta* and *S. recta* of CONRAD, and also a new form here described as *Orthis loricula*, all from the horizon of the Trenton limestone. These shells have an elongate hinge-line, and their external expression is much like that of STROPHOMENA, a resemblance which is increased by the presence of the convex deltidium suggesting a divergence at this point from ORTHIS toward STROPHOMENA.

HEBERTELLA
(nom. propos).

V. Group of ORTHIS SINUATA, Hall.

PLATE VA, FIGS. 1-13.

1843. *Orthis*, CONRAD. Proc. Acad. Nat. Sci. Phila., vol. i, p. 333.
1847. *Orthis*, HALL. Palæontology of N. Y., vol. i, pp. 118, 125-128, pl. xxxii, figs. 3, 12; pl. xxxiia, fig. 2 and pl. xxxiib, figs. 1, 2.
1859. *Orthis*, BILLINGS. Canadian Nat. and Geol., vol. iv, pp. 435, 436, figs. 11-14.
1862. *Orthis*, BILLINGS. Palæozoic Fossils, vol. i, p. 137, fig. 114.
1863. *Orthis*, BILLINGS. Geology of Canada, p. 129, figs. 55, 56; p. 167, figs. 148, 150 and p. 210, fig. 210.
1873. *Orthis*, MEEK. Palæontology Ohio, vol. i, pp. 96, 99, 101, pl. viii, fig. 4, and pl. ix, figs. 1-3.
1875. *Orthis*, MILLER. Cincinnati Quart. Jour. Sci., vol. ii, pp. 28, 34, 36, 40.
1875. *Orthis*, WHITE. Geogr. and Geol. Expl. west 100th Merid. p. 70, pl. iv, fig. 11.
1881. *Orthis*, WHITE. Tenth Ann. Rept. Indiana State Geol., p. 117, pl. ii, figs. 10-12.
1882. *Orthis*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 260, pl. xii, figs. 17, 18.
1882. *Orthis*, MILLER. Journ. Cincinnati Soc. Nat. Hist., vol. v, p. 40, pl. i, fig. 5.
1883. *Orthis*, HALL. Rept. N. Y. State Geologist for 1882, pl. xxxiv, figs. 31-34; pl. xxxv, figs. 16-22.
1884. *Orthis*, WALCOTT. Palæontology Eureka District, p. 74, pl. xi, fig. 6.
1885. *Orthis*, FOERSTE. Bull. Denison University, vol. i, pp. 85, 87, pl. xiii, figs. 13, 15, 16, 20, 21.
1887. *Orthis*, SHALER. Memoirs Kentucky Geol. Survey, plate viii.
1889. *Orthis*, NETTLEROTH. Kentucky Fossil Shells, p. 36, pl. xxxiv, figs. 14-20.

This division is distinguished both by its external and internal characters; the pedicle-valve has a well developed, often much elevated cardinal area and a long, straight hinge-line; its surface is depressed-convex, always less convex than the opposite valve which is frequently gibbous or inflated. The surface is covered with a great number of fine, rounded, closely crowded plications which increase rapidly by intercalation, and are crossed by lamellose growth-lines, and fine concentric striæ. On the interior of the pedicle-valve the teeth are large and supported by thick lamellæ which are continued as a strong ridge around a short, obcordate muscular area. This area is medially divided by a prominent ridge upon the summit of which lies the linear scar of the adductors. The flabellate lateral impressions are sometimes divisible into their two components, diductors and adjustors, and in old individuals the impression of the pedicle-muscle is often distinct.

In the brachial valve the dental sockets are narrow and are enclosed beneath and on the inner side by the strong crural plates. The cardinal process is elongate and simple, sometimes thickened, often crenulate, but not lobed at its posterior extremity. This process unites with the inner bases of

the crural plates and is produced forward as a median ridge dividing the four muscular scars, which are distinctly developed only in old shells.

The shell-structure is fibrous-impunctate, and the plications of the surface sometimes tubulose.

Shells of this type of structure are abundant in the Trenton and Hudson faunas and extend upward into the Clinton group but are not at present known in any later period.

ORTHOSTROPHIA, Hall. 1883.

VI. Group of Orthis strophomenoides, Hall.

PLATE VA, FIGS. 22-27.

1857. *Orthis*, Hall. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 46.
1859. *Orthis*, Hall. Palæontology of N. Y., vol. iii, pp. 177, 481, pl. xiv, fig. 2 and pl. xxiii, fig. 7.
1869. *Orthis*, Safford. Geology of Tennessee, pp. 328, 533.
1883. *Orthostrophia*, Hall. Rept. N. Y. State Geol. for 1882, pl. xxxvi, figs 32-34.

This section is represented by impunctate, resupinate shells, having the external characters of those included in Groups IV and V. In the interior of the pedicle-valve the muscular area is deeply excavated, very confined, and limited almost to the narrow space between the dental lamellæ. The adductor scars appear to be extremely minute and linear, while the cardinals occupy the rest of the area. The margin of this area is thickened and elevated, and is so contracted as to convey, at first, the impression that it is no more than a rather large rostral cavity. In the opposite valve the muscular area is similarly confined but the quadrilobate character of the impression is very decided. The lateral components are divided by a strong median ridge, and the entire area is deeply impressed in the substance of the shell. The cardinal process is elongate and simple at its posterior extremity, the crural plates and crura strong.

The vascular and ovarian markings are a conspicuous feature of these shells and are almost invariably developed with remarkable distinctness. In the pedicle-valve two or three large vascular trunks originate near the anterior edge of the muscular area, divide a few times in their passage over the pallial region, the branches rapidly multiplying near the margin. In the opposite valve the main sinuses are four in number, originating in pairs at the ante-

lateral margins of the anterior adductors. The outer member of each pair curves quite abruptly toward the cardinal angle, while the inner members curve outward and then inward, all ramifying as they approach the margins of the shell. The umbo-lateral spaces enclosed by the curvature of these sinuses in both valves, and the central space in the brachial valve, are covered with linear dendritic ovarian striæ.

The only well known representative of this group is the *Orthostrophia strophomenoides*, of the Lower Helderberg fauna, with which the *Orthis Halli*, of SAFFORD, described from the Lower Helderberg of Perry county, Tennessee, is probably synonymous.

This species is the latest known representative of the impunctate orthids, and furnishes an interesting example of the persistence of an external form characterizing earlier faunas, accompanied by radical modifications of the interior. The Niagara species, *Orthis fasciata*, Hall, and the two species, *Orthis mimica* and *O. socialis*,* described by BARRANDE, from the Etage D, have interiors very similar in structure to that of ORTHOSTROPHIA. These are, however, small, non-resupinate shells.

PLATYSTROPHIA, KING. 1850.

VII. Group of ORTHIS BIFORATA, (Schlotheim) Davidson.

TEREBRATULITES BIFORATUS, Schlotheim.

PLATE VB, FIGS. 1-10.

1820. *Terebratulites*, SCHLOTHEIM. Petrefacktenkunde auf ihr. jetz. Standpunkt, p. 265.
1830. *Terebratula*, VON EICHWALD. Nat. Skizze von Podolien, p. 202.
1830. *Porambonites* (*partim*), PANDER. Beitr. zur Geognosie Russlands, p. 96.
1837. *Atrypa*, HISINGER. Lethæa Suecica, p. 76.
1840. *Spirifer*, VON BUCH. Ueber Delthyris, p. 44.
1840. *Spirifer*, VON EICHWALD. Silurische Schichten-System von Esthland, p. 144.
1842. *Delthyris*, EMMONS. Geology of N. Y.; Rept. Second District, p. 396.
1842. *Delthyris*, CONRAD. Jour. Acad. Nat. Sci. Phil., vol. viii, p. 260.
1843. *Delthyris*, HALL. Geology of N. Y.: Report Fourth District, p. 70.
1843. *Spirifer*, CASTELNAU. Essai sur le Syst. silur. de l'Amérique septentrionale, p. 42.
1844. *Delthyris*, OWEN. Geol. Exploration Iowa, Wisconsin, Illinois, pl. 15.
1845. *Delthyris*, DE VERNEUIL. Géol. de la Russie, vol. ii, p. 135.
1846. *Delthyris*, McCOY. Synopsis Silur. Fossils Ireland, p. 37.
1847. *Delthyris*, HALL. Palæontology of N. Y., vol. i, p. 131.

* Système Silurien, vol. v, pl. 63, figs. I, III.

1848. *Orthis*, Davidson. Bull. Soc. Géol. France, 2d ser., vol. v, p. 323.
1848. *Spirifera*, Phillips and Salter. Mem. Geol. Survey United Kingdom, vol. ii, p. 293.
1850. *Platystrophia*, King. Monogr. Permian Fossils England, p. 106.
1851. *Orthis*, Quenstedt. Handb. der Petrefactenkunde, p. 486.
1852. *Spirifer*, Hall. Palæontology of N. Y., vol. ii, p. 65.
1852. *Spirifer*, McCoy. British Palæoz. Fossils, p. 192.
1853. *Orthis*, Davidson. Introd. British Foss. Brachiopoda, plate viii, figs. 146-148.
1856. *Orthis*, Billings. Canadian Naturalist and Geologist, vol. i, p. 206.
1858. *Delthyris*, Rogers. Geology of Pennsylvania, vol. ii, p. 820.
1859. *Orthis*, Salter. Murchison's Siluria, 2d ed., p. 210.
1859. *Orthis*, Hall. Twelfth Rept. N. Y. State Cab. Nat. Hist., p. 66.
1860. *Orthis*, Lindström. Gotland's Brachiopoder, p. 371.
1863. *Orthis*, Billings. Geology of Canada, Report of Progress, p. 167.
1865. *Platystrophia*, Shaler. Bull. Musem Comparative Zool., No. 4, p. 67.
1866. *Orthis*, Salter. Mem. Geol. Survey United Kingdom, vol. iii, pp. 259, 267, 276.
1871. *Orthis*, Davidson. British Silurian Brachiopoda, p. 268.
1873. *Orthis* (*Platystrophia*), Meek. Geol. Survey Ohio: Palæontology, vol. i, p. 114.
1874. *Orthis* (*Platystrophia*), James. Cincinnati Quart. Journ. Sci., vol. i, p. 20.
1874. *Orthis*, Nicholson and Hinde. Canadian Journal, p. 158.
1875. *Orthis*, White. Geogr. and Geol. Expl. west 100th Merid., p. 71.
1875. *Orthis*, Miller. Cincinnati Quar. Journ. Sci., vol. ii, p. 25.
1875. *Orthis*, Nicholson. Rept. Palæontology Prov. Ontario, p. 16.
1878. *Orthis* (*Platystrophia*), James. The Palæontologist, No. 1, p. 7.
1880. *Orthis*, White. Second Ann. Rept. State Bureau Stat. and Geol., Indiana, p. 487.
1881. *Orthis*, White. Tenth Report State Geologist Indiana, p. 119.
1883. *Platystrophia*, Hall. Thirty-sixth Rept. N. Y. State Mus. Nat. Hist., p. 34.
1883. [*Platystrophia*], Hall. Rept. N. Y. State Geologist for 1882, pl. 34.
1885. *Orthis*, Foerste. Bull. Denison University, vol. i, p. 80.
1887. *Platystrophia*, Shaler. Mem. Kentucky Geol. Surv., vol. i, pt. 3, pp. 43, 44.
1889. *Orthis*, Nettelroth. Kentucky Fossil Shells, p. 35.
1889. *Platystrophia*, Hall. Bull. Geol. Society America, vol. 1, p. 19.

The name Platystrophia proposed by Dr. King, has come into very general use for a group of orthids having a strikingly spiriferoid exterior. The hinge-line and area are long and straight and nearly equally developed on the two valves. Both valves are very convex, the brachial being the more so and bearing a very strong median fold corresponding to a deep sinus on the opposite valve. The valves are marked by strong, sharp plications, which extend over the fold and sinus, and the external surface is finely granulose, the latter feature being rarely well retained. This peculiar exterior, so unlike anything met with elsewhere in the genus Orthis, readily deceived earlier writers into referring the species to Delthyris or Spirifer,* and Mr. Davidson

* Von Buch, 1840, Ueber Delthyris; von Eichwald, 1840, Silur. Schichten-system in Esthland; Emmons, 1842, Geol. of N. Y.; Rept. Second Dist.; Conrad, 1842, Jour. Acad. Nat. Sci. Phila.; Hall, 1843, Geol. of N. Y.; Rept. Fourth District; de Verneuil, Géol. de la Russie; McCoy, Synopsis Silur. Foss. Ireland; Phillips and Salter, Mem. Geol. Surv. United Kingdom; Hall, 1847, 1852, Palæontology of N. Y., vols. i and ii.

was the first to demonstrate* the true generic value of its internal and more essential characters. These are not materially different from those already described in the group of *Orthis occidentalis.* The delthyrium is open in both valves, being somewhat larger in the pedicle-valve, and in old and gibbous shells of *Orthis lynx* has often encroached to a considerable extent upon the umbonal region of the valve. The teeth are thick and very prominent, the muscular area comparatively small, but usually deeply excavated in the substance of the shell, and not readily divisible into the component scars. In the brachial valve the cardinal process is a simple linear ridge, always small and sometimes nearly obsolete. The dental sockets are comparatively small, the crural plates large and thick, uniting at their inner bases and produced into a prominent median ridge. The muscular area is quadruplicate and indistinct. The shell-structure is very compact and finely fibrous, without punctation.

PLATYSTROPHIA is represented by a series of forms, all commonly regarded as referable to SCHLOTHEIM'S *Terebratulites biforatus*, or as presenting only varietal differences from this species. The genus appears in American faunas first in the Chazy and ranges upward into the Clinton and Niagara groups, attaining a great development in individuals and variety in external form in the Trenton-Hudson River fauna. It has also a considerable vertical range in the Silurian of Great Britain, Mr. DAVIDSON citing it from the Caradoc, Upper and Lower Llandeilo and the Wenlock.†

HETERORTHIS

(nom. propos).

VIII. Group of ORTHIS CLYTIE, Hall.

PLATE VB, FIGS. 20-24.

1861. *Orthis*, HALL. Fourteenth Rept. N. Y. State Cab. Nat. Hist., p. 90.
1862. *Orthis*, HALL. Fifteenth Rept. N. Y. State Cab. Nat. Hist., pl. ii, fig. 4, 5.
1875. *Orthis*, MILLER. Cincinnati Quart. Jour. Sci., vol. ii, p. 34.
1875. *Orthis*, HALL and WHITFIELD. Geology of Ohio; Palæontology, vol. ii, p. 75, pl. i, figs. 18, 19.

The species *Orthis Clytie*, from the Trenton horizon at Frankfort, Kentucky, is the sole representative of a peculiar strophomenoid or leptænoid exterior accompanied by internal characters which are distinctly orthoid, but quite pe-

* Bull. de la Soc. Géol. de France, vol. xxi, 2d ser., 1848.

† DAVIDSON, British Silurian Brachiopoda, p. 272.

culiar. The shell is transversely oval, with a straight hinge-line and rounded cardinal extremities; its form is depressed plano-convex, the convexity of the pedicle-valve being slight. The cardinal area is about equally developed on each valve. The surface is ornamented by fine, rounded, radiating striæ between each two of which are from two to six much finer radiating lines: all these are crenulated by exceedingly faint growth-lines.

The interior of the pedicle-valve has short teeth with prominent extremities, and inconspicuous dental lamellæ. The muscular impression is large and consists of a small adductor scar situated centrally, and two lateral scars which are flabellate and greatly elongated, but not uniting in front and enclosing the adductor as is usual in typical forms of ORTHIS. These lateral scars are divided into subordinate impressions, of which the outer posterior members may represent the adjustors. In the brachial valve the dental sockets are obscure, the crural plates oblique, terminating abruptly at the bases of the crura, their lower part being continued in a low ridge surrounding a short subcircular muscular area, which is very obscurely quadrilobate. The cardinal process has a vertical, sharp, simple, posterior edge, but is much thickened where it unites with the crural plates, and is produced along the muscular area as a prominent median ridge. From the ante-lateral margins of the muscular area radiate six low, somewhat sinuous ridges of similar character to those frequently seen in members of Group XI. Both valves are considerably thickened just within the margins, as in many strophomenoids.

The shell-structure is finely fibrous and perforated by minute punctations which are in general sparsely developed, but most distinctly arranged in radiating rows corresponding to the surface striæ.

Orthis Clytie is the only representative of this type of structure known in the American Silurian, but with it may be associated SOWERBY'S *O. alternata* * and McCOY'S † *O. retrorsistria*, both from the Caradoc horizon. The former of these is a very close ally to the American Trenton form in all its external specific characters.

* SOWERBY, in Murchison's Silurian System, p. 638, pl. xix, fig. 6; 1839, and DAVIDSON, Silurian Brachiopoda, p. 264, pl. xxxi, figs. 1, 3, 7; Suppl. p. 187, pl. xiv, figs. 1–6.

† McCOY, British Palæozoic Fossils, p. 224, pl. i II, figs. 12, 13; 1852, and DAVIDSON, Silurian Brachiopoda, p. 265, pl. xxxi, figs. 2, 4–6; pl. xxxvi, figs. 39–42; Suppl. p. 185, pl. xiv, figs. 7–16.

BILOBITES, Linné. 1775.

IX. Group of Orthis biloba, Linné.

Anomia biloba, Linné.

PLATE VB, FIGS. 11-19.

1775. *Bilobites*, Linné. Systema Naturæ. ed. Müller, vol. vi, p. 325.
1815. *Terebratula*, J. Sowerby. Trans. Linn. Soc., vol. xii, p. 516.
1826. *Terebratula*, Hisinger. Anteckn. Act. Royal Soc., Holm., pl. 7.
1827. *Delthyris?* Dalman. Vetensk. Svenska Akad. Hand., p. 124, pl. 3, fig. 7.
1828. *Delthyris*, Hisinger. Bidrag till Sveriges geognosi, vol. iv, p. 220.
1837. *Spirifer*, von Buch Abhandl. Königl. Akad. d. Wissensch. zu Berlin, p. 49.
1837. *Delthyris*, Hisinger. Lethæa Suecica, p. 74.
1838. *Delthyris*, Conrad Second Ann. Rept. Geol. N. Y., pp. 112, 118.
1838. *Terebratula* (*Delthyris?*) Angelin. Museum Palæont. Suecicum.
1839. *Spirifer*, Sowerby. Murchison's Silurian System, p. 630.
1842. *Delthyris*, Conrad Journ. Acad. Nat. Sci. Phila., vol. viii, p. 262.
1843. *Delthyris*, Hall. Geology of N. Y. ; Rept. Fourth District, p. 105.
1847. *Spirifer*, de Verneuil. Bull. Soc. Géol., France, 2d ser., vol. iv.
1848. *Orthis*, Davidson. Bull. Soc. Géol., France, 2d ser., vol. v, p. 321.
1849. *Spirifer*, Hall. American Journal Science, vol. xx, p. 228.
1850. *Dicœlosia*, King. Monogr. Perm. Fossils, England, p. 106.
1852. *Orthis*, McCoy. British Palæozoic Fossils, p. 213.
1852. *Spirifer*, Hall. Palæontology of N. Y., vol. ii, p. 260.
1853. *Orthis*, Davidson. Introd. British Fossil Brachiopoda, p. 101, plate viii, figs. 141–145.
1859. *Orthis*, Salter. Murchison's Siluria, 2d ed., p. 543.
1859. *Orthis*, Hall. Palæontology of N. Y., vol. iii, p. 179.
1859. *Orthis*, Hall. Twelfth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 85.
1860. *Orthis*, Lindström. Gotland's Brach. : Ofver. Kong. Akad. Förhandl., p. 370.
1866. *Orthis*, Ramsay and Salter. Mem. Geol. Survey United Kingdom, vol. iii, pp. 267, 361.
1868. *Orthis*, Davidson. Trans. Geol. Soc. Glasgow, Pal. Series, vol. i, pl. 2, fig. 2.
1869. *Orthis*, Davidson. British Silurian Brachiopoda, p. 206.
1882. *Orthis*, Hall. Eleventh Ann. Rept. State Geologist Indiana, p. 286.
1883. *Orthis* [*Dicœlosia*], Hall. Rept. N. Y. State Geologist for 1882, plate xxxv.
1884. *Orthis*, Davidson. British Fossil Brachiopoda, General Summary, pp. 377, 433.
1888. *Orthis*, Ringueberg. Proc. Acad. Nat. Sci. Phila., p. 134.
1889. *Bilobites*, Hall. Bulletin Geological Soc. America, vol. i, p. 21.

Shells small, strongly bilobed. Hinge-line short ; teeth and sockets obscure ; cardinal process small and simple. Crural plates thin and very long, often extending as far forward as the commencement of the lobation. Muscular area indistinct, larger in the brachial than in the pedicle-valve. Shell-substance fibrous and punctated by coarse tubules apparently arranged in radiating rows.

This group comprises but two species, *Orthis biloba*, Linné and *O. varica*,

Conrad.* The former has a very considerable range, appearing, according to DAVIDSON† in the Caradoc, Lower and Upper Llandovery, Woolhope, Wenlock and Ludlow formations.

In America it has been found only in the Niagara group, while its congener, *Orthis varica*, Conrad, a very distinct species,‡ is confined to the Lower Helderberg fauna.

DALMANELLA

(nom propos).

X. Group of ORTHIS TESTUDINARIA, Dalman.

PLATE VB, FIGS. 25-39; AND PLATE VC, FIGS. 1-17.

1828. *Orthis*, DALMAN. Kongl. Vet. Acad. Handl., pp. 115, 117, pl. ii, fig. 4.
1842. *Orthis*, EMMONS. Geology of N. Y.; Rept. Second Dist., p. 404, fig. 4.
1842. *Orthis*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 139, fig. 4.
1843. *Orthis, Atrypa?* HALL. Geology of N. Y.; Rept. Fourth Dist., p. 105, fig. 6; p. 175, fig. 4, and p. 271, fig. 4.
1843. *Orthis*, CONRAD. Proc. Acad. Nat. Sci., Phila., vol. i, p. 133.
1847. *Orthis*, HALL. Palæontology of N. Y., vol. i, pp. 117, 118, 120, 128, pl. xxxii, figs. 1, 2, 5, and pl. lxxix, fig. 4.
1852. *Orthis*, HALL. Palæontology of N. Y., vol. ii, p. 152, pl. lii, fig. 3.
1856. *Orthis*, BILLINGS. Canadian Nat. and Geol., vol. i, p. 40, fig. 1, and p. 136, pl. 2, fig. 5.
1857. *Orthis*, BILLINGS. Rept. of Progress Geol. Surv. Canada for 1856, p. 296.
1857. *Orthis*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 42, figs. 1, 2, and p. 44, fig. 1.
1859. *Orthis*, HALL. Palæontology of N. Y., vol. iii, pp. 168–172, pl. xii, figs. 1–21, and pl. xiii, figs. 1–12.
1859. *Orthis*, BILLINGS. Canadian Nat. and Geol., vol. iv, p. 434, fig. 10.
1860. *Orthis*, F. ROEMER. Sil. Fauna westl. Tennessee, p. 62, pl. v, fig. 7.
1860. *Orthis*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 121.
1862. *Orthis*, HALL. Geology of Wisconsin, vol. i, p. 42, fig. 7 and p. 436.
1862. *Orthis*, BILLINGS. Palæozoic Fossils, vol. i, p. 79, fig. 72.
1862. *Orthis*, HALL. Fifteenth Rept. N. Y. State Cab. Nat. Hist., pl. ii, figs. 1–3.
1863. *Orthis*, BILLINGS. Geology of Canada, pp. 130, 165, 231, 312, figs. 57, 144, 246, 320.
1867. *Orthis*, HALL. Palæontology of N. Y., vol. iv, p. 35, 46, 62, pl. v, figs. 1, 2; pl. vi, fig. 1 and pl. viii, figs. 3–8.
1868. *Orthis*, MEEK and WORTHEN. Geology of Illinois, vol. iii, p. 373, pl. vii, fig. 6.
1873. *Orthis*, MEEK. Palæontology of Ohio, vol. i, pp. 103, 109, 112, pl. viii, figs. 1–3, 5.
1874. *Orthis*, JAMES. Cincinnati Quart. Jour. Sci., vol. i, p. 19.
1875. *Orthis*, MILLER. Cincinnati Quart. Jour. Sci., vol. ii, pp. 20, 22, 24, 30.

* The *Orthis acutiloba* of RINGUEBERG is a form of *O. biloba* in which the lobes are very divergent. All stages of variation between this extreme and the normal form for the species are readily detected in any large collection.

† British Silurian Brachiopoda, p. 208.

‡ DAVIDSON (Silurian Brachiopoda, p. 207) and QUENSTEDT (Petrefactenkunde Deutschlands, pl. lv, figs. 67–70), erroneously regarded this species as indentical with *O. biloba*.

1875. *Orthis*, White. Geogr. and Geol. Expl. west 100th Merid., pp. 55, 72.
1878. *Orthis*, Calvin. Bull. U. S. Geol. and Geogr. Surv Terr., vol. iv., p. 728.
1879. *Orthis*, Hall. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., p. 150, pl. xxi, figs. 11-17.
1880. *Orthis*, N. H. Winchell. Eighth Ann. Rept. Geol. Nat. Hist. Surv. Minnesota. pp. 63, 64.
1882. *Orthis*, Whitfield. Geology of Wisconsin, vol. iv, p. 258, pl. xii, figs. 5-7 and p. 320, pl. xxv, figs. 3, 4.
1882. *Orthis*, Hall. Eleventh Rept. State Geologist of Indiana, p. 285, pl. xxi, figs. 11-17.
1883. *Orthis*, Hall. Report N. Y. State Geol. for 1882, pl. xxxiv, figs. 1-24 and pl. xxxv, figs. 23-27.
1884. *Orthis*, Walcott. Palæontology Eureka Dist., p. 72, pl. xi. figs. 3, 10.
1885. *Orthis*, Foerste. Bull. Denison University, vol. i. pp. 84, 85. pl. xii. fig. 11; pl. xvii. fig. 13.
1889. *Orthis*, Nettleroth. Kentucky Fossil Shells, p. 37, pl. xxxii, figs. 55-57.
1889. *Orthis*, Whitfield. Bull. American Mus. Nat. Hist., vol. ii. p. 43, pl. viii. fig. 1-4.
1889. *Orthis*, Beecher and Clarke. Mem. N. Y. State Mus. Nat. Hist., vol. i. No. 1, p. 14, pl. i, figs. 3-11.

Shells plano-convex or subequally biconvex. Pedicle-valve usually the deeper, often gibbous, elevated at the umbo and arched over the cardinal area. Hinge-line generally shorter than the greatest width of the shell. In many of the species there is a more or less conspicuous, undefined median fold and sinus on the pedicle and brachial valves respectively. Surface covered with fine, rounded bifurcating striæ.

In the pedicle-valve the teeth are quite prominent, thickened at their extremities and supported by lamellæ which are produced forward circumscribing a rather short suboval or subquadrate muscular area, which is more or less distinctly defined in different species and in different conditions of the shell. In *Orthis Meeki*, Miller, a somewhat ponderous, biconvex, multistriate variation of *Orthis testudinaria*, it is clearly resolvable into adjustor and diductor scars, the latter bounding, but not altogether enclosing the impression of the adductors; the pedicle-scar is also discernible. In the brachial valve the cardinal process extends forward as a ridge to the bases of the crural plates, where it is broadened and continued thence as a median ridge separating the muscular impressions. The inner surface of this process is divided by a faint median furrow which produces two lobes at the posterior extremity, and each of these lobes is again divided, making the process quadrilobate. Sometimes the inner divisions of the two main lobes have coalesced, producing a strong median lobe and thus making the process appear trilobate. In some species at maturity, and in others from abnormal growth this process becomes a broad plug, which fills the entire delthyrial opening. The dental sockets are small, the crural plates

often greatly elevated, especially in the plano-convex forms, and they are not usually produced into a ridge about the muscular area, but end abruptly. Muscular impressions quadruplicate, sometimes with radiating ridges extending from the lateral and anterior margins.

Shell-substance finely fibrous and punctate.

This group has a large specific representation and a noteworthy vertical range. It appears to have had its inception in the Chazy fauna, *Orthis subæquata*, Conrad, being perhaps the earliest known representative. In the Trenton and Hudson River faunas are *Orthis testudinaria* and its close allies, *O. emacerata*, *O. Meeki*, *O. multisecta*, with a number of other species; in the Niagara, *O. elegantula*; in the Lower Helderberg, *O. perelegans*, *O. concinna*, *O. planoconvexa*, *O. subcarinata*; in the Corniferous, *O. lenticularis*, Vanuxem, not Wahlenberg; in the Hamilton, *O lepida*, and in the Chemung, *O. superstes*, sp nov. With the close of the Devonian the type seems to have disappeared.

There is a considerable difference in the external expression of the forms included in this group, and the plano-convex species like *O. elegantula*, *O. Wisbyensis*, *O. basalis*, *O. planoconvexa*, *O. subcarinata*, which are readily distinguished from other members of the section. Some of the internal characters of these forms are also expressive; the flat brachial valve gives a great elevation to the crural plates, and the depth of the pedicle-valve makes the dental plates correspondingly high. These internal characters must necessarily vary in their development with the variation in convexity of the valves but it is doubtful if any subdivision of the group based upon these features could be of permanent value.

In these species there is again occasionally found evidence of the secretion of an apical callosity in the delthyrium of the pedicle-valve, a feature which has been observed in *Orthis perveta* and *O. elegantula*. Of additional interest is the peculiar crenulation or pectination of the inner surface of the high crural plates in *Orthis elegantula*, and some other species, a character highly developed in both teeth and sockets in Tropidoleptus and in Atrypa.

RHIPIDOMELLA, ŒHLERT. 1890.

RHIPIDOMYS, ŒHLERT. 1887.

XI. Group of ORTHIS MICHELINI, Léveillé.

TEREBRATULA MICHELINI, Léveillé.

PLATE VI, FIGS. 1-16, 19-21; PLATE VIA, FIGS. 1-22; AND PLATE VII, FIGS. 1-10.

1843. *Orthis*, HALL. Geology of N. Y.: Rept. Fourth Dist., p. 71, fig. 1, and p. 105, fig. 7.
1852. *Orthis*, OWEN. Geol. Surv. Wisconsin, Iowa and Minnesota, p. 585, pl. iiia, fig. 10.
1852. *Orthis*, HALL. Palæontology of N. Y., vol. ii, p. 56, pl. xx, fig. 6, and p. 253, pl. lii, fig. 4.
1856. *Orthis*, BILLINGS. Canadian Nat. and Geol., vol. i, p. 131, pl. ii, fig. 1.
1857. *Orthis*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 41, fig. 1-5; p. 42, figs. 1, 2; p. 46, and p. 135, figs. 1-7.
1858. *Orthis*, HALL. Trans. Albany Institute, vol. iv, p. 12.
1858. *Orthis*, HALL. Geology of Iowa, vol. i, pt. ii, p. 596, pl. xii, fig. 4; pp. 486, 487, pl. ii, figs. 1-3.
1858. *Orthis*, MARCOU. Geology of North America, p. 48, pl. vi, fig. 14.
1858. *Orthis*, SWALLOW. Trans. St. Louis Acad. Sci., vol. i, p. 218.
1859. *Orthis*, HALL. Palæontology of N.Y., vol. iii, pp. 162, 164-167, 175, 409, 481, pl. x, figs. 1-22; pl. xa, figs. 4-12; pl. xi, figs. 1-14; pl. xv, fig. 1; pl. xci, figs. 1-3; pl. xcv, figs. 1-7; pl. xcva, figs 20, 21.
1860. *Orthis*, BILLINGS. Canadian Journal, vol. v, pp. 267, 269, figs. 14-16.
1860. *Orthis*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., pp. 78-80, figs. 1, 2.
1860. *Orthis*, F. ROEMER. Sil. Fauna westl. Tennessee, p. 63, pl. v, fig. 6.
1860. *Orthis*, SWALLOW. Trans. St. Louis Acad. Sci., vol. i, p. 639.
1860. *Orthis*, WHITE. Journ. Bost. Soc. Nat. Hist., vol. vii, p. 231.
1862. *Orthis*, WHITE and WHITFIELD. Proc. Bost. Soc. Nat. Hist., vol. viii, p. 292.
1862. *Orthis*, A WINCHELL. Proc. Acad. Nat. Sci., Phila., vol. xiv, p. 409.
1863. *Orthis*, HALL. Sixteenth Rept. N. Y. State Cab. Nat. Hist, pp. 32-35.
1863. *Orthis*, SWALLOW. Trans. St. Louis Acad. Sci., vol. ii, p. 81.
1863. *Orthis*, BILLINGS. Geology of Canada, p. 369, fig. 385 and p. 384, fig. 417.
1864. *Orthis*, MEEK. Palæontology of California, vol. i, p. 10, pl. ii, fig. 5.
1865. *Orthis*, SHALER. Bull. No. 4, Mus. Comp. Zool., p. 66.
1865. *Orthis*, A. WINCHELL. Proc. Acad. Nat. Sci., Philadel., p. 116.
1866. *Orthis*, BILLINGS. Catalogue Silurian Foss. Island Anticosti, p. 42.
1867. *Orthis*, HALL. Palæontology of N. Y., vol. iv, pp. 34, 36, 38, 40, 41, 45, 47, 48, 50, 52, 63, pl. iv, figs. 1-10; pl. v, figs. 4, 6-10; pl. vi, figs. 2, 3; pl. vii, figs. 1, 2, 4; pl. viii, figs. 2, 9, 10; p. lxiii, figs. 1-5.
1868. *Orthis*, MEEK and WORTHEN. Geology of Illinois, vol. iii, p. 371, pl. vii, fig. 7.
1870. *Orthis*, A. WINCHELL. Proc. American Philosophical Soc., vol. xii, p. 251.
1872. *Orthis*, MEEK. Palæontology of Eastern Nebraska, p. 173, pl. i, fig. 8.
1873. *Orthis*, MEEK and WORTHEN. Geology of Illinois, vol. v, p. 591, pl. xxv, fig. 4.
1874. *Orthis*, BILLINGS. Palæozoic Foss., vol. ii, p. 32, figs. 14-16; p. 35, pl. iii, fig. 4.
1874. *Orthis*, DERBY. Bull. Cornell University, vol. i, p. 26, pls. v, viii.
1875. *Orthis*, WHITE. Geogr. and Geol. Expl. west 100th Merid., p. 125, pl. ix, fig. 5.
1877. *Orthis*, MEEK. U. S. Geological Expl. 40th Parallel, vol. iv, p. 63, pl. vii, fig. 1.
1879. *Orthis*, HALL. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., p. 149, pl. xxi, figs. 18-25.
1881. *Orthis*, MILLER. Journ. Cincinnati Soc. Nat. Hist., vol. iv, p. 8, pl. vii, fig. 8.
1882. *Orthis*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 320, pl. xxv, figs. 1, 2.

1882. *Orthis*, WHITFIELD. Bull. No. 3, American Mus. Nat. Hist., p. 45, pl. vi, figs. 1–5.
1882. *Orthis*, HALL. Eleventh Rept. State Geologist of Indiana, p. 285, pl. xxi, figs. 18–25.
1883. *Orthis*, HALL. Twelfth Rept. State Geologist of Indiana, p. 324, pl. xxix, figs. 1–5.
1883. *Orthis*, HALL. Rept. N. Y. State Geologist for 1882, pl. xxxvi, figs. 1–16, 19–21 and pl. xxxvii, figs. 1–4.
1883. *Orthis*, WHITE. Twelfth Rept. U. S. Geol. Surv. Terr., p. 164, pl. xli, fig. 4.
1885. *Orthis*, FOERSTE. Bull. Denison University, p. 83, pl. xiii, fig. 10.
1887. *Rhipidomys*, ŒHLERT. Fischer's Manual de Conchyliologie; Brachiopodes, p. 1288.
1888. *Orthis*, HERRICK. Bull. Denison University, vol. iii, p. 38, pl. v, fig. 9.
1889. *Orthis*, NETTELROTH. Kentucky Fossil Shells, p. 39, pl. xxxii, figs. 32–35; pp. 40, 45, pl. xvi, figs. 4–6, 12–14, 23, 24 and pl. xvii, figs. 33–35.
1889. *Orthis*, SIMPSON. American Philosophical Soc., p. 437, fig. 1.
1889. *Orthis*, BEECHER and CLARKE. Mem. N. Y. State Museum, p. 17, pl. i, figs. 13–18.
1890. *Rhipidomella*, ŒHLERT. Journal de Conchyliologie.

This is a large and very compact group of orthids, fundamentally characterized by the large flabelliform muscular scars of the pedicle-valve, but having in association with this a number of other peculiarities of importance. The shells are subcircular in outline, biconvex and sublenticular, with the brachial valve somewhat the deeper. The hinge-line is short, the cardinal area narrow, especially on the brachial valve. The surface bears a slight median depression on each valve, and is covered with fine, rounded, subequal striæ which are hollow, often opening upon the surface; these openings probably representing the broken bases of short tubular spines.

The pedicle-valve bears two strong diverging teeth, planted firmly upon the valve at the bottom of the delthyrium, and extending upward and outward at their extremities: and from their bases a more or less strongly defined curving ridge extends forward, bordering the muscular area. The muscular area extends from one-third to five-sixths the length of the valve and is deeply impressed; the pedicle-scar fills the entire rostral cavity; the adductors occupy a small central scar which is completely enveloped by the great diductors. A median ridge arises in front of the adductors, dividing the diductors; sometimes the former rest upon a general anterior flattening of this ridge, and in rare instances, the ridge divides the separate components of the adductor impression. The margin of the entire muscular area is thickened and elevated, and outside of this are deeply pitted ovarian markings.

In the brachial valve the dental sockets are deep and narrow, the crural plates extremely prominent, sometimes supporting short crura. The cardinal

process is erect, strongly arched on its anterior face, often very thick and greatly elevated; the edge of its posterior face is multilobate, the posterior surface itself having a trilobed appearance. The muscular area is quadruplicate, comparatively small and usually indistinct. A broad, low, median ridge extends forward from the base of the cardinal process. The shell-structure is coarsely fibrous and very strongly punctate, the perforations being large and generally more abundant along the furrows between the striæ.

Dr. ŒHLERT's term RHIPIDOMYS=RHIPIDOMELLA, which was founded on the *Terebratula Michelini*, Léveillé,* must be extended to include what proves to be the largest of the subordinate divisions of ORTHIS. Shells of this type, though attaining their greatest numerical and specific development in the Devonian and Carboniferous, appeared in America as early as the age of the Clinton fauna, in the typically developed species *O. circulus*. In the Niagara group its representation is limited to the species *O. hybrida*, a shell which rarely, if ever, attains the size in America that it does in the Wenlock of Great Britain and the Island of Gotland. From this point onward the species in the following faunas rapidly multiply; the Lower Helderberg fauna containing the forms *O. oblata*, *O. discus*, *O. eminens*, *O. tubulostriata*, and that of Oriskany, *O. musculosa*, the largest member of the group, with an extravagant development of the muscular scars. They reach their culmination in the Devonian, gradually declining and finally disappearing with the close of the Carboniferous age. In the faunas of the latter there is occasionally manifested a variation in the expression of these species, without change in the essential points of structure. The *O. Penniana*, Derby, from the Coal Measures of Itaitúba, Brazil, has an elongate-subovate outline, and a very short hinge-line; *Orthis Pecosi*, Marcou, is a shell of much the same character, while in *O. incisiva*, Waagen, and *O. dubia*, Hall, the hinge-line has become so short that the shell is actually tere-

* WAAGEN had previously regarded this species as the type-form of a well defined group in the Carboniferous, to which he referred the three species occurring in the Salt-Range: *O. corallina*, Waagen, *O. Pecosi*, Marcou, *O. incisiva*, Waagen. (See Memoirs Geolog. Surv. India; Palæontologia Indica, Ser. xiii, vol. iv (fas. 3), p. 562. 1884.)

The term RHIPIDOMYS having already been used for a genus of mammals. Dr. ŒHLERT has proposed the term RHIPIDOMELLA.

bratuliform. In the latter species no trace of the cardinal area remains on either valve on account of the encroachment of the delthyrium.

In these shells there is occasionally developed a tendency to close the delthyrium of the brachial valve. This is never carried very far, but in some species where the cardinal process attains a great size, as in *O. Penelope*, *O. musculosa*, and others, it more than fills the delthyrial cavity, pressing upward the thinner, unsupported portion of the cardinal area, where it covers the dental sockets.

SCHIZOPHORIA, King. 1850.

XII. Group of Orthis resupinata, Martin.

Conchyliolithus anomites resupinata, Martin.

PLATE VI, FIGS. 17, 18, 22-31; AND PLATE VIA, FIGS 25-32.

1809. *Conchyliolithus anomites*, Martin. Petref. Derb., tab. xlix, figs. 13, 14.
1813. *Anomia*, Schlotheim. Min. Taschenbuch, vol. viii, pl. 1, fig. 6.
1820. *Terebratulites*, Schlotheim. Die Petrefactenkunde auf ihrem jetzigen Standpunkte, pp. 253, 254.
1822. *Terebratula*, Sowerby. Mineral Conchology, vol. iv, p. 25.
1822. *Hysterolithes*, Schlotheim. Petrefactenkunde, p. 247.
1836. *Spirifera*, Phillips. Geology of Yorkshire, vol. ii, pl. xi, fig. 12.
1840. *Spirifera*, von Buch. Mém. Soc. Géol. de France, vol. iv, pl. 10, fig. 32.
1842. *Orthis*, Vanuxem. Geology of N. Y.; Rept. Third District, pp. 163, 164.
1843. *Orthis*, Hall. Geology of N. Y.; Rept. Fourth Dist., p. 215.
1843. *Orthis*, de Koninck. Description des Animaux Fossiles de Belgique, pl. xiii, fig. 9.
1844. *Orthis*, McCoy. Syn. Carb. Fossils Ireland, pl. xx, fig. 20.
1850. *Schizophoria*, King. Monogr. Permian Fossils of England, p. 106.
1851. *Hysterolithes*, Quenstedt. Handbuch der Petrefact., p. 484.
1857. *Orthis*, Hall. Tenth Rep. N. Y. State Cab. Nat. Hist., pp. 45, 110.
1857. *Orthis*, Cox. Owen's Geological Survey Kentucky, vol. iii, p. 570.
1858. *Orthis*, Hall. Rept. Geol. Surv. Iowa, vol. i, pt. 2, pp. 488, 489, 597.
1859. *Orthis*, Hall. Palæontology of N. Y., vol. 3, p. 176.
1859. *Orthis*, Billings. Hind's Rep. Expl. Assiniboine, Saskatchewan, etc., p. 193.
1861. *Orthis*, Davidson. British Carb. Brachiopoda, p. 130.
1862. *Orthis*, A. Winchell. Proc. Acad. Nat. Sci. Phil., vol. xiv, p. 410.
1867. *Orthis*, Hall. Palæontology of N. Y., vol. iv, pp. 43, 55, 58, 59, 60.
1868. *Orthis*, Meek. Transactions Chicago Acad. Sci., vol. i, pp. 88, 90.
1868. *Orthis*, Meek and Worthen. Geological Survey of Illinois, vol. iii, pp. 423, 424.
1874. *Orthis*, Derby. Bull. Cornell University, vol. i, p. 63.
1877. *Orthis*, Hall and Whitfield. U. S. Geol. Expl. 40th Par., vol. iv, p. 265.
1881. *Orthis*, White. Second Ann. Rept. Bureau Stat. and Geol. Indiana, p. 133.
1882. *Orthis*, Whitfield. Geology of Wisconsin, vol iv, pt. 3, Palæontology, p. 326.
1883. [*Schizophoria*, Hall. Rept. N. Y. State Geologist for 1882, pl. xxxvi.
1883. *Schizophoria*, Hall. Thirty-sixth Rept. N. Y. State Mus. Nat. Hist., p. 75.
1884. *Orthis*, Walcott. Palæontology Eureka District, pp. 114, 115.
1889. *Orthis*, Nettelroth. Kentucky Fossil Shells, p. 43.

The species comprising this group have a very close external resemblance to the resupinate shells included under Groups IV, V and VI. There are still some differences. In these the hinge-line is shorter, the shells often proportionally narrower, the cardinal area of the pedicle-valve less elevated; the ornamentation of the surface is striate but much more finely; the striæ are hollow, tubulose and produced into short spines,* as in RHIPIDOMELLA.

The interior presents an arrangement of the muscular scars very similar to that seen in *O. sinuata* and its allies. In the pedicle-valve there is a short subquadrate or obcordate area with thickened, elevated margins, and deeply sunk in the substance of the shell; in the opposite valve a less distinctly defined, quadripartite area. In SCHIZOPHORIA, however, the adductor impression occupying the summit of the median ridge dividing the muscular area of the pedicle-valve, is more distinct, the hinge-teeth are more divergent and less ponderous; in the brachial valve the crural plates are much less divergent and more erect; the cardinal process, which in young shells, has much the same character as in RHIPIDOMELLA, becomes absorbed and thus narrowed with age making a thin and sharp ridge; concomitant with this change is the formation, in the delthyrial cavity, of one, two or even three minor ridges on each side of the original process, so that in old shells the posterior face of the process appears to be multilobate In the very convex brachial valve, four (rarely six) deep pallial sinuses take their origin at the anterior margin of the muscular area, passing forward as broad, simple, subparallel bands, to near the margin of the valve, where they bifurcate and become arborescent. To these differences must be added one of distinctive importance, viz., the abundantly punctate character of the shell-structure.

In America the earliest representative of the group is the species here described as *Schizophoria senecta* from the Clinton fauna, this type of structure being thus coeval with that of RHIPIDOMELLA. In the Lower Helderberg fauna is *Orthis multistriata*, Hall, which is followed in the Corniferous limestone by *O. propinqua*, Hall, in the Hamilton by *O. Tulliensis*, Hall, and in the later Devonian by *O. Iowensis*, Hall, *O. impressa*, Hall, *O. Macfarlanii*, Meek, *O. Tioga*, Hall,

* See DAVIDSON, British Carboniferous Brachiopoda, pl. xxx, fig. 1*d*.

O. carinata, Hall. In the Lower Carboniferous are *O. Swallowi*, Hall, *O. resupinata*, Martin (?), and in the Coal Measures, *O. resupinoides*, Cox.

The term HYSTEROLITHUS was applied by some early non-binomial writers to internal casts of these shells together with others, mostly spiriferoids, having the same general aspect. The term HYSTEROLITES was used by LINNÉ * and SCHLOTHEIM† with more especial reference to the internal casts of *Orthis striatula*, Schlotheim, a characteristic member of this group, and the name has been resuscitated by some later writers, but nothing would be gained by the adoption of this term in place of SCHIZOPHORIA, especially as its early use was vague and without generic signification.

ORTHOTICHIA

(nom. propos).

XIII. Group of ORTHIS ? MORGANIANA, Derby.

PLATE VII, FIGS. 41-45.

From a personal examination of examples of this species, and from Dr. DERBY's detailed description and illustration,‡ it appears to be very closely allied in all external and many internal characters to the resupinate shells constituting the sub-genus SCHIZOPHORIA. The essential point of divergence is in the presence of a thin, elevated median septum longitudinally dividing the muscular area of the pedicle-valve, this, with the prominent dental lamellæ, making three vertical plates in this valve. The character thus given to the interior, as shown in figures 6, 7, 9, 11, plate iii, of Dr. DERBY's work, is altogether distinct from that in *Orthis resupinata* and its allies, for while in these shells there is often a more or less prominent thickened median muscular fulcrum, it does not become a septum; futhermore, the muscular area, which in SCHIZOPHORIA is deeply impressed and bordered by a thickened margin is not so in *Orthis ? Morganiana*, but appears to be on the same level with the general interior surface and faintly defined at its anterior edge. In the brachial valve the species has the multipartite cardinal process and the arrangement of mus-

* Museum Tessinianum, p. 90, 1755.

† Die Petrefactenkunde, p. 247, 1820.

‡ Bulletin of the Cornell University, vol. 1, No. 2, pp. 29-32, pl. iii, figs. 1-7, 9, 11, 34; pl. iv, figs. 6, 14, 15, 1874.

cular scars as in SCHIZOPHORIA. Although Dr. DERBY emphasizes the latter feature as of especial importance on account of its being composed of three pairs of scars, it has been shown that this area in SCHIZOPHORIA is of the same character when distinctly defined, a condition not often observed. (See *Orthis impressa*, Plate VI A, fig. 28.)

Orthis? Morganiana apparently represents a passage-form between SCHIZOPHORIA and ENTELETES, though its predominant characters are distinctly orthoid.* Dr. WAAGEN refers to the same group his species, *Orthis marmorea* and *O. Derbyi*, from the Carboniferous beds of the Salt-Range of India; *O.? Morganiana* is from the Coal Measures of Itaitúba, Brazil.

ENTELETES, FISCHER DE WALDHEIM. 1830.

(WAAGEN, emend. 1884.)

XIV. Group of ENTELETES LAMARCKI, Fischer de Waldheim.

PLATE VII A, FIGS. 44-54.

1825. *Choristites (partim)*, FISCHER DE WALDHEIM. Programme sur la Choristites.
1830. *Enteletes*, FISCHER DE WALDHEIM. Oryctogr. du Gouv. de Moscou, p. 144, tab. 26, figs. 6, 7.
1837. *Choristites (partim)*, FISCHER DE WALDHEIM. Oryctogr. du Gouv. de Moscou, p. 141, tab. 24, figs. 10, 11.
1842. *Terebratula*, D'ORBIGNY. Voyage dans l'Amérique Meridionale, Pal., p. 45, pl. iii, figs. 14-16.
1845. *Spirifer (partim)*, DE VERNEUIL. Géol. de la Russie d'Europe et des Montagnes de l'Oural, p. 152, pl. vi, figs. 8 a, b.
1852. *Spirifer*, HALL. Stansbury's Rept. Expl. Great Salt Lake, p. 409, pl. iv, figs. 3 a, b.
1865. *Syntrielasma*, MEEK and WORTHEN. Proc. Acad. Nat. Sci. Phila., p. 277.
1866. *Rhynchonella*, GEINITZ. Carbon. und Dyas in Nebraska, p. 37, pl. iii, figs. 1-4.
1866. *Syntrielasma*, MEEK. Geol. Survey of Illinois; Palæontology, vol. ii, p. 223, fig. 36; p. 324, fig. 37.
1872. *Syntrielasma*, MEEK and WORTHEN. Palæontology of Eastern Nebraska, p. 117, pl. vi, fig. 1; pl. viii, fig. 12.
1873. *Syntrielasma*, MEEK and WORTHEN. Geol. Survey of Illinois; Palæontology, vol. v, p. 571, pl. xxvi, fig. 20.
1874. *Syntrielasma*, DERBY. Bull. Cornell University, vol. i, p. 62.
1876. *Orthis*, TRAUTSCHOLD. Die Kalkbrüche von Mjatschkowa II, p. 70, pl. viii, fig. 3.
1883. *Syntrielasma*, KAYSER. Richthofen's China, vol. iv, p. 179, pl. xxiv, figs. 2, 3
1884. *Enteletes*, WAAGEN. Mem. Geol. Surv. India; Palæontologia Indica, Ser. xiii, i, iv (fas. 3), p. 550.
1884. *Enteletes*, DAVIDSON. General Summary of British Fossil Brachiopoda, p. 377.

DIAGNOSIS. "Coquille sub-arrondie ressemblant pour la forme à une Térébratule, présentant de petits becs sur les deux valves, mais la charnière est

* See remarks by MR. MEEK given in DERBY's paper, *loc. cit.*, and by WAAGEN, Salt-Range Fossils, Brachiopoda, p. 564.

tellement unie et close, que les deux bords avancent un peu au dessus de la coquille. La charnière est très courte."—FISCHER DE WALDHEIM. 1830 (*loc. cit.*).

"The general outline of the shells is more or less globular, with mostly very strongly inflated valves. The hinge-line is short, never projecting at the extremities; both valves are more or less strongly plicated radially.

"The ventral valve is always smaller than the dorsal one The area of the ventral valve is sometimes high and strongly reclining, sometimes not; but laterally little extended, according to the short hinge-line. It is cut open in the middle by a tolerably large triangular fissure, which is never covered up by a pseudo-deltidium.

"The dorsal valve is always larger than the ventral one, with a strongly bent-over and sometimes rolled-in beak. The area is mostly small in this valve and even sometimes linear. The deltidial fissure is smaller than in the other valve.

"Both valves are covered all over with a very fine radial striation, similar to that occurring in many species of ORTHIS, and it appears not improbable that also in ENTELETES fine hair-like spines were disseminated irregularly over this striation. The minute structure of the shell is punctate." * * *

"Internally the ventral valve bears two strong elongated teeth on both sides of the triangular fissure, supported by very strong dental plates, which extend from the apex toward the front of the valve; but instead of diverging they approach each other toward the middle of the valve, bending around, either with a gentle curve or a sudden bend. Between these dental plates, beginning as a low ridge at the apex, a thin blade-like median septum extends; it is highest toward the middle of the valve and then suddenly terminates."

"The dorsal valve has interiorly two very strong septa, which extend on both sides of the deltidial fissure, and project for a certain distance, strongly diverging into the interior of the valve. They support strong and long curved crura, which have exactly the shape of a boar's tusks. They are laterally compressed and bear on their lower and inner side a sharp prominent ridge. The dental sockets are placed exteriorly to the origin of the crura. In the middle, at the apex of the valve, a small cardinal process is observable, having the form of a short narrow ridge."—WAAGEN (*loc. cit.*).

Type, *Enteletes Lamarcki*, Fischer de Waldheim, Upper Carboniferous limestone.

American example, *Spirifer hemiplicatus*, Hall, Upper Carboniferous.

Observations. Dr. Waagen has shown the necessity of adopting for these shells the early term Enteletes, as Fischer's figures accompanying his diagnosis prove to be of the well-known fossil *Spirifer Lamarcki*, although his description, sufficient for the purposes of that time, is of little value in establishing his genus. The regret expressed by Dr. Waagen at being compelled to supercede Meek and Worthen's term, Syntrielasma, will be generally felt, especially as these authors had characterized their genus very accurately and illustrated it with care: they also demonstrated its close relationship to Orthis. This appears externally in the bi-perforate cardinal areas, uncovered delthyria, and tubulo-striate surface. It has already been suggested that these forms are linked to the punctate resupinate species of Orthis (Schizophoria) through the *Orthis? Morganiana* of Derby. Though the shells are extremely globose, and their sharply plicated surface is not to be found among species of the genus Orthis, they are distinctly resupinate; the interior characterized by the great development of the crural plates in the brachial valve, and the three plates in the opposite valve, which are orthoid features carried to an extreme development. The cardinal process is small, erect and multilobate. The muscular markings have not been determined; it is evident from analogy with Schizophoria that in the pedicle-valve the muscular area was limited to the very narrow space between the two lateral septa and was divided by the median partition; in the brachial valve the wider space between the crural plates is also divided by a faint median ridge.

Before Dr. Waagen's study of the Salt-Range faunas but two species of this genus were well known; one the *Enteletes Choristites* or *Spirifer Lamarcki*, of the Upper Carboniferous limestone of Mjatschkowa, Russia; the other *Syntrielasma hemiplicatum*, Hall, sp., from a corresponding horizon in America.

Dr. Waagen has added seven species, and proposed a subdivision of the genus as follows: ventrisinuati: *A*, group of *Enteletes hemiplicatus*, Hall (sp.), *i. e.*, forms with a ventral sinus: dorsosinuati, forms with a ventral fold; *A*, group of *Enteletes ferrugineus*, Waagen, subequally convex shells; *B*, group of *Enteletes pentameroides*, Waagen, extremely gibbous species of pentameroid aspect. To

the second division is referred the shell described by GEINITZ,* from the Upper Carboniferous or Permian of Nebraska, as *Rhynchonella angulata*, Linné. According to MEEK and WAAGEN, the Carboniferous species, *Terebratula Andii* and *T. Gaudryi*, of D'ORBIGNY, from Bolivia, are to be referred to ENTELETES.

Future study of the species of ORTHIS which have not been accessible during the preparation of this work, will no doubt necessitate the establishment of still other groups of equivalent value to those here proposed; but there will, of course, always remain forms of intermediate structure which can not be included in any strict classification. It is, however, gratifying to find relatively so few species which can not be placed under the foregoing subdivisions.

There is a small group of shells exemplified by such forms as *Orthis punctata*, de Verneuil, from Gotland, and *O. punctostriata*, Hall, from the Niagara fauna, which have a true orthoid interior but a peculiar external form, and a surface covered by radiating rows of circular superficial punctæ, very similar to those marking the genus PORAMBONITES. Other species for which it is difficult to find a place in this grouping are a few of the type of *O. Bouchardi*, Davidson, *O. Nisis*, Hall, and *O. rugiplicata*, Hall. The early species which have been referred to ORTHIS require especially careful consideration. From later study of the species described by Mr. BILLINGS, from the Quebec group, examples of which have been kindly furnished by the Directors of the Geological Survey of Canada, and of the Redpath Museum of Montreal, it is shown that one of them, *O. gemmicula*, must be removed to another genus; another, *O. apicalis*, is very doubtfully an ORTHIS; while *O. Mycale* and *O. Tritonia* appear to have no cardinal process in the brachial valves; *O. Hippolyte*, which in external features might be classed with the punctate group of *O. testudinaria*, is an impunctate shell. The species *O. Armanda* and *O. Corinna* have a leptænoid form, and their relations are evidently quite remote from typical ORTHIS. These species

*Carbon. and Dyas in Nebraska, p. 37, pl. iii, figs. 1-4. Mr. MEEK regarded this as identical with *Enteletes hemiplicatus* (Report Palæontology of Eastern Nebraska, p. 178. 1872)

together with *O. platys*, Billings, from the Chazy, *O. Saffordi*, sp. nov., and probably *O. Holstoni*, Safford, from the Trenton, form a small group distinguished by its peculiar exterior, though the internal characters of the species are still undetermined. To establish the true generic value of all these forms will require much patient work both in the field and in the laboratory.

The orthids occurring in primordial faunas have in so many instances shown a comprehensive structure, having characters which individually are distinctive of Orthis, Orthothetes, Clitambonites, Scenidium, etc., that it may be questioned whether any of these primordial forms can be included under Orthis according to the strict definition of the term, or even under any of the subdivisions here proposed.

The development of the punctated shell-structure in this genus is a peculiar phenomenon.* In eight of the thirteen proposed subdivisions of Orthis, the shell-structure is prismatic but impunctate. So far as now known there is not an impunctate Orthis in the faunas later than the Silurian. On the other hand the punctate species are decidedly in the minority in Silurian faunas, attaining their great numerical development in the Devonian. The first appearance of punctation is along the line of the *O. testudinaria* group (Dalmanella), but evidence is still required to show that some of the earliest species included in this

* Thin sections of these shells have been made whenever material has been favorably preserved or in sufficient quantity to allow it, and no evidence has been found of an indiscriminate or sporadic appearance of this punctation, though it has, naturally, been impossible to study the shell-structure in every species examined. It was originally a part of the plan and purpose of this work to take up the study of the minute shell-structure in connection with the generic studies, and to include the result of the investigation in this volume, as a part of the contribution to our knowledge of the Palæozoic Brachiopoda. The lapse of nearly twenty years from the commencement of this work till it was again taken up, in 1888,† has brought much new material for consideration, while the studies and publications of numerous authors have served to present the subject in new aspects, and at the same time to demand a somewhat different treatment from that originally contemplated. Owing to these conditions the study of the shell-structure has been postponed for the present, but it is the ultimate purpose of the author to take up as a special subject the examination of the minute shell-structure in the different genera of Palæozoic Brachiopoda.

† The work of a revision of the genera of the Palæozoic Brachiopoda was begun soon after the completion and publication of Volume IV of the Palæontology of New York, and thirty plates, beginning with illustrations of the generic group of Orthis had already been lithographed, from drawings chiefly made by Mr. R. P. Whitfield, when it became necessary to suspend the work. These plates, originally numbered from AV to XXXVI, were mostly lithographed by Mr. Philip Ast, two of them by Swinton, two by Riemann and two by Bergman, between the years 1870 and 1876. Of these plates AV and V have been cancelled, and, with large additional material and accumulated information, have been substituted by V, Va, Vb, Vc. The original plates, from VI to XIX, are included in this volume, and are supplemented by VIa, VIIa, XIa, XIb, XIc, XId, XVa, XX

group are actually punctate. It is not surprising to find some primordial species of ORTHIS, for example *O. Billingsi* (PROTORTHIS), affording indications of a punctated shell, which, with other characters, may be interpreted as showing relationship to CLITAMBONITES and the streptorhyncheids in which a punctate structure is never wanting.

It should not be forgotten that a grouping of the species of ORTHIS was made by DE VERNEUIL in 1845,* and by QUENSTEDT in 1871.† The very broad conception of generic values which generally prevailed at the date of the former work, but which at the latter period were maintained by few students, renders these groupings of little value in the present state of our knowledge. In DE VERNEUIL'S classification, based upon thirty-five species and varieties of "ORTHIS," were two groups of the first order, A, *Sinuatæ*, corresponding to KING'S SCHIZOPHORIA, and B, *non-Sinuatæ*. The latter was divided into a[1], *striatæ*, b[1], *plicosæ*. The *striatæ* were again divided, a[2], *arcuostriatæ*, in which the delthyrium is open, and b[2], *rectostriatæ*, in which the delthyrium is closed. The former of these included the a[3], *uniareæ*, with a rudimentary area on the brachial valve (ex. *O. elegans*, Bouchard), and b[3], *biareæ*, with areas developed on both valves. Of the *biareæ* were two subdivisions, a[4], *filiareæ* (ex. *O. Michelini* = RHIPIDOMELLA; *O. tetragona* = SCHIZOPHORIA); b[4], *elegantulæ* (ex. *O. elegantula*, *O. parva* = DALMANELLA). Of b[2], *rectostriatæ*, were also the subdivisions a[3], *uniareæ*, and b[3], *biareæ*, and of the former of these two groups a[4], with three or more secondary striæ in the furrows (= ORTHOTHETES); b[4], with but one or two such striæ (= MEEKELLA, STREPTORHYNCHUS, DERBYA, ORTHOTHETES); of the latter, *biareæ*, were a[4], GONAMBONITES (= CLITAMBONITES), and b[4], PRONITES (= CLITAMBONITES and ORTHISINA). The b[1], *plicosæ*, were divided into those with simple plications (*O. calligramma*), and those with dichotomous plications (*O. extensa*, Pander).

QUENSTEDT instituted three principal divisions of his ORTHIDÆ: (1) *ventriplexæ*, with convex pedicle-valve; (2) *ventricavæ* or *expansæ*, with concave pedicle-valve; (3) *dorsicavæ*, with concave brachial valve. Representatives of the first include SCHIZOPHORIA, PORAMBONITES, ORTHISINA, CLITAMBONITES, STREPTORHYNCHUS,

* Geol. Russ. et des mont. de l'Ural.

† Petrefactenkunde Deutschlands: Brachiopoden.

Bilobites, Orthis, Dalmanella, Rhipidomella, Orthothetes, Anoplotheca, Leptocœlia, Tropidoleptus. In the second group were placed species belonging to the genera Brachyprion, Strophodonta, Plectambonites, Leptæna, Productus, Chonetes, Stricklandinia; in the third were Strophomena, Strophonella and Orthothetes.

LIST OF GENERA AND SPECIES.

The subdivisions here proposed for the genus Orthis, in its broader significance and usual acceptation, some of them under old names and others under new, are well founded in nature. This arrangement is the result of a careful study of a very extensive series of the American representatives of this genus, and of the nearly two hundred species which are currently referred to Orthis, a very large percentage will readily take their places in the proposed classification. It will be borne in mind that after the elimination of synonymous terms there still remain a considerable number of names, founded upon imperfect or obscure material, which are of little aid to the student of palæontology; others, upon fossils of great rarity or from horizons of uncertain age. In the following list of American species, which is appended in order to show the adaptability of this grouping, nearly all the members have been studied from actual specimens, the star preceding the names indicating this fact; the other species included being only those of which the original descriptions and figures have afforded some definite clue to their relation with these groups.

ORTHIS, Dalman (as restricted).

I. Group of Orthis callactis, Dalman.

* O. costalis,	Hall	Chazy.
†* O. orthambonites,	Billings	Quebec.
* O. Euryone,	Billings	Quebec.
* O. Hippolyte,	Billings	Quebec.
* O. disparilis,	Conrad.	Trenton.
* O. tricenaria,	Conrad	Trenton and Hudson River.
* O. flabellulum,	Sowerby	Niagara.
* O. Davidsoni,	de Verneuil	Niagara.

PLECTORTHIS
(nom. propos).

II. Group of Orthis plicatella, Hall.

* O. æquivalvis,	Hall	Trenton and Hudson River.
* O. plicatella,	Hall	Trenton and Hudson River.
*[?]O. Ella,	Hall	Hudson River.
* O. fissicosta,	Hall	Hudson River.
* O. Jamesi,	Hall	Hudson River.
* O. Kankakensis,	McChesney	Hudson River.
*[?]O. sectostriata,	Ulrich	Hudson River.
* O. triplicatella,	Meek	Hudson River.
* O. Whitfieldi,	N. H. Winchell	Hudson River.
* O. dichotoma,	Hall	Hudson River.
[??] O. aurelia,	Billings	Lower Devonian.

† This species was identified by Billings with *O. orthambonites*, Pander; but that author used Orthambonites only as a generic term, though it was subsequently taken by von Buch and von Eichwald as a specific designation to include all the species referred by Pander to this genus. As a specific term, it must, therefore, be accredited to von Buch, and it is synonymous with some one (it is impossible to say which) of Pander's species. It appears to be quite distinct from the *O. calligramma*, var. *orthambonites*, de Verneuil, with which the Quebec species is compared by Mr. Billings, and it should therefore receive a new name.

DINORTHIS
(nom. propos).

III. Group of Orthis pectinella, Emmons.

* O. pectinella,	Emmons	Trenton.
O. pectinella, var. semiovalis,	Hall	Trenton.
* O. Sweeneyi,	N. H. Winchell	Trenton.

PLÆSIOMYS
(nom. propos).

IV. Group of Orthis subquadrata, Hall.

O. Iphigenia,	Billings	Trenton.
* O. porcata,	McCoy	Trenton and Hudson River.
O. retrorsa,	Salter	Trenton and Hudson River.
* O. subquadrata,	Hall	Trenton and Hudson River.
* O. deflecta,	Conrad	Trenton.
* O. recta,	Conrad	Trenton.
* O. loricula,	sp. nov.	Trenton.

HEBERTELLA
(nom. propos).

V. Group of Orthis sinuata, Hall.

O. Battis,	Billings	Quebec.
O. imperator,	Billings	Chazy.
* O. bellarugosa,	Conrad	Trenton.
* O. borealis,	Billings	Trenton.
O. Lonensis,	Walcott	Trenton.
* O. insculpta,	Hall	Hudson River.
* O. occidentalis,	Hall	Hudson River.
* O. sinuata,	Hall	Hudson River.
O. Scovillii,	Miller	Hudson River.
* O. Maria,	Billings	Anticosti.
* O. Daytonensis,	Foerste	Clinton.
* O. fausta,	Foerste	Clinton.

ORTHOSTROPHIA, Hall. 1883.

VI. Group of Orthis strophomenoides, Hall.

*[?]O. fasciata,	Hall	Niagara.
* O. Halli,	Safford	Lower Helderberg.
* O. strophomenoides,	Hall	Lower Helderberg.

PLATYSTROPHIA, King. 1850.

VII. Group of Orthis biforata, Schlotheim.

* O. biforata,	Schlotheim	Chazy—Clinton.
* O. acutilirata,	Conrad	Hudson River.
* O. crassa,	James	Hudson River.
* O. laticosta,	Meek	Hudson River.
* O. lynx,	von Eichwald	Hudson River.

HETERORTHIS
(nom. propos).

VIII. Group of Orthis Clytie, Hall.

* O. Clytie,	Hall	Trenton.

BILOBITES, Linné. 1775.

IX. Group of Orthis biloba, Linné.

* O. biloba,	Linné	Niagara.
* O. varica,	Conrad	Lower Helderberg.

DALMANELLA
(nom. propos).

X. Group of Orthis testudinaria, Dalman.

* O. Electra,	Billings	Quebec.
*[?]O. Evadne,	Billings	Quebec.

* O. Macleodi,	WHITFIELD	Calciferous.
* O. subæquata,	CONRAD	Chazy—Trenton.
* O. Minneapolis,	N. H. WINCHELL	Trenton.
O. gibbosa,	BILLINGS	Trenton.
* O. perveta,	CONRAD	Trenton.
* O. Stonensis,	SAFFORD	Trenton.
* O. testudinaria,	DALMAN	Trenton—Hudson River.
* O. bellula,	MEEK	Hudson River.
* O. crispata,	EMMONS	Hudson River.
* O. emacerata,	HALL	Hudson River.
* O. Meeki,	MILLER	Hudson River.
* O. multisecta,	MEEK	Hudson River.
* O. elegantula, var parva,	FOERSTE	Clinton.
* O. elegantula,	DALMAN	Niagara.
* O. arcuaria,	sp. nov.	Niagara.
* O. concinna,	HALL	Lower Helderberg.
* O. perelegans,	HALL	Lower Helderberg.
* O. planoconvexa,	HALL	Lower Helderberg.
* O. quadrans,	HALL	Lower Helderberg.
* O. subcarinata,	HALL	Lower Helderberg.
* O. lenticularis,†	VANUXEM, non WAHLENBERG,	Upper Helderberg.
* O. lepida,	HALL	Hamilton.
* O. infera,	CALVIN	Chemung.
* O. Leonensis,	HALL	Chemung.
* O. superstes,	sp. nov.	Chemung.

RHIPIDOMELLA, ŒHLERT. 1890.

XI. Group of ORTHIS MICHELINI, Léveillé.

* O. circulus,	HALL	Clinton.
* O. uberis,	BILLINGS	Anticosti.
* O. hybrida,	SOWERBY	Niagara.
* O. assimilis,	HALL	Lower Helderberg.

† The specific name *lenticularis* having already been used for a species of ORTHIS, the name should be changed to *Orthis lentiformis*, Hall. See Report of the Fourth Geological District of New York, page 175.

O. discus,	Hall	Lower Helderberg.
* O. eminens,	Hall	Lower Helderberg.
* O. oblata,	Hall	Lower Helderberg.
* O. tubulostriata,	Hall	Lower Helderberg.
* O. Cumberlandia,	Hall	Oriskany.
* O. musculosa,	Hall	Oriskany.
* O. alsus,	Hall	Schoharie.
* O. peloris,	Hall	Schoharie.
* O. Cleobis,	Hall	Corniferous.
* O. Livia,	Billings	Corniferous.
O. Semele,	Hall	Corniferous.
* O. Vanuxemi,	Hall	Hamilton.
* O. Vanuxemi, var. pulchella,	Herrick	Waverly.†
* O. cyclas,	Hall	Hamilton.
* O. idonea,	Hall	Hamilton.
* O. Leucosia,	Hall	Hamilton.
* O. Penelope,	Hall	Hamilton.
* O. solitaria,	Hall	Hamilton.
* O. suborbicularis,	Hall	Hamilton.
* O. Pennsylvanica,	Simpson	Chemung.
[?] O. cuneata,	Owen	Devonian.
O. Lucia,	Billings	Devonian.
O. occasus,	Hall	Waverly.
O. subelliptica,	White and Whitfield	Waverly.
* O Missouriensis,	Swallow	Choteau.
* O. Burlingtonensis,	Hall	Burlington.
O. Dalyana,	Miller	? Burlington.
* O. Thiemii,	White	Burlington.
O. Clarkensis,	Swallow	Keokuk.
* O. Oweni,	sp. nov.	Knobstone.‡
* O. dubia,	Hall	St. Louis.

† There is a larger form of Orthis in the Waverly of Ohio, which has a very gibbous brachial valve, and can not be regarded as identical with this variety of *O. Vanuxemi*.

‡ The "Knobstone group" of Owen, in Kentucky and the southern part of Indiana, in its lowest members, has been generally regarded as of the age of the Waverly of Ohio. Its upper member has been paralleled with the Keokuk, but the limitation between these formations is not always well defined or easily determined.

	O. Nevadensis,	MEEK	Carboniferous.
*	O. Pecosi,	MARCOU	Coal Measures.
*	O. Penniana,	DERBY	Carboniferous.

SCHIZOPHORIA, KING. 1850.

XII. Group of ORTHIS RESUPINATA, Martin.

*	O. senecta,	sp. nov.	Clinton.
*	O. multistriata,	HALL	Lower Helderberg.
[?]	O. peduncularis,	HALL	Lower Helderberg.
*	O. propinqua,	HALL	Corniferous.
*	O. Macfarlanii,	MEEK	Upper Devonian.
*	O. Tulliensis,	HALL	Tully.
*	O. Iowensis,	HALL	Chemung.
*	O. carinata,	HALL	Chemung.
*	O. impressa,	HALL	Chemung.
*	O. Tioga,	HALL	Chemung.
*	O. Swallovi,	HALL	Burlington.
*	O. resupinata,	MARTIN	Lower Carboniferous.
*	O. resupinoides,	COX	Coal Measures.

ORTHOTICHIA

(nom propos).

XIII. Group of ORTHIS (?) MORGANIANA, Derby.

*	O. (?) Morganiana,	DERBY	Coal Measures.

ENTELETES, FISCHER DE WALDHEIM. 1830.

XIV. Group of ENTELETES LAMARCKI, Fischer de Waldheim.

*	Enteletes hemiplicatus,	HALL	Coal Measures.

SUPPLEMENTARY NOTE ON THE GENUS ORTHIS.

In the foregoing list of species, the form currently known in this country as *Orthis flabellulum*, from the Clinton-Niagara fauna, is arranged with the typical division of the genus. In a previous provisional arrangement it was placed under the group DINORTHIS, in association with *O. pectinella*. There are excellent reasons for its position in either association. With the typical orthids it agrees in the simple plications of the surface, and in the character of the muscular impressions in both valves. Attention is especially directed to this conformity in the pedicle-valve, where the outline of the muscular area is the more variable throughout the entire genus; and the figure 40, upon Plate V,* shows its oval form and restricted extent, similar to that seen in *Orthis calligramma*, var. *Davidsoni* (fig. 5), and *Orthis costalis* (fig. 15) The species is however a distinctly resupinate shell, as shown on Plate V, fig. 39; the pedicle-valve, in the umbonal region, is quite as deep as the brachial, but is gently depressed over the pallial region, while the brachial valve remains convex throughout. To associate this species with the typical forms of ORTHIS, would open that division to the reception of resupinate shells, thus destroying its homogeneity. On the basis of external characters the shell belongs to the group DINORTHIS, but it does not agree with *Orthis pectinella* in its muscular impressions, so that it must be regarded as a form connecting the typical Orthides with DINORTHIS: though, in geological time, appearing at the end of the two groups.

The original identification of this Niagara species as *Orthis flabellulum. (a)?* was made in 1843,† from comparison with the figure given by SOWERBY, in Murchison's Silurian System (pl. xxi, fig. 8). This figure did not indicate with clearness either the resupination of the shell or the outline of the muscular scars, and the identification, made with doubt, has been accepted as final.

The elaborate illustration of the British species of this name given by Mr. DAVIDSON at a later date,‡ shows that it is strongly resupinate and has a subquadrate muscular area in the pedicle-valve, features which at once associate it with DINORTHIS, and it is further evident that it is a close ally in all its characters with the American species *O. pectinella*, though in the latter the bifurcation of the plications, which appears to be normal for *O. flabellulum*, Sowerby (var. β), is of less frequent occurrence. These two forms are from equivalent horizons. For nearly fifty years an erroneous identification, though made with the best lights of that time, and expressed with doubt, has been current in American literature. In the Twentieth Report on the New York State Cabinet of Natural History (1867, p. 397), the term *Orthis flabellites*, Hall, was used for the species in a list of the fossils occurring in the limestones of the Niagara group in Wisconsin, Illinois and Iowa; and although no discussion or explanation of the reference was there given, the name was intended to supercede the use of *O. flabellulum*.

* An additional figure of this valve, showing these characters with greater distinctness, will be given upon a supplementary plate at the close of this work.

† Geology of New York; Report Fourth District, p. 107.

‡ 1859. Silurian Brachiopoda, pl. xxxiv, figs. 1–12a.

The erroneous reference of this species has but recently been corrected, in part, by Mr. A. F. FOERSTE,† who has pointed out some of the differences already mentioned, and has proposed to retain the species (as it stands in the list) associated with *O. calligramma*, var. *flabellites*. While indisposed to continue a resupinate shell in this association, the necessity of another name for the American species is evident.

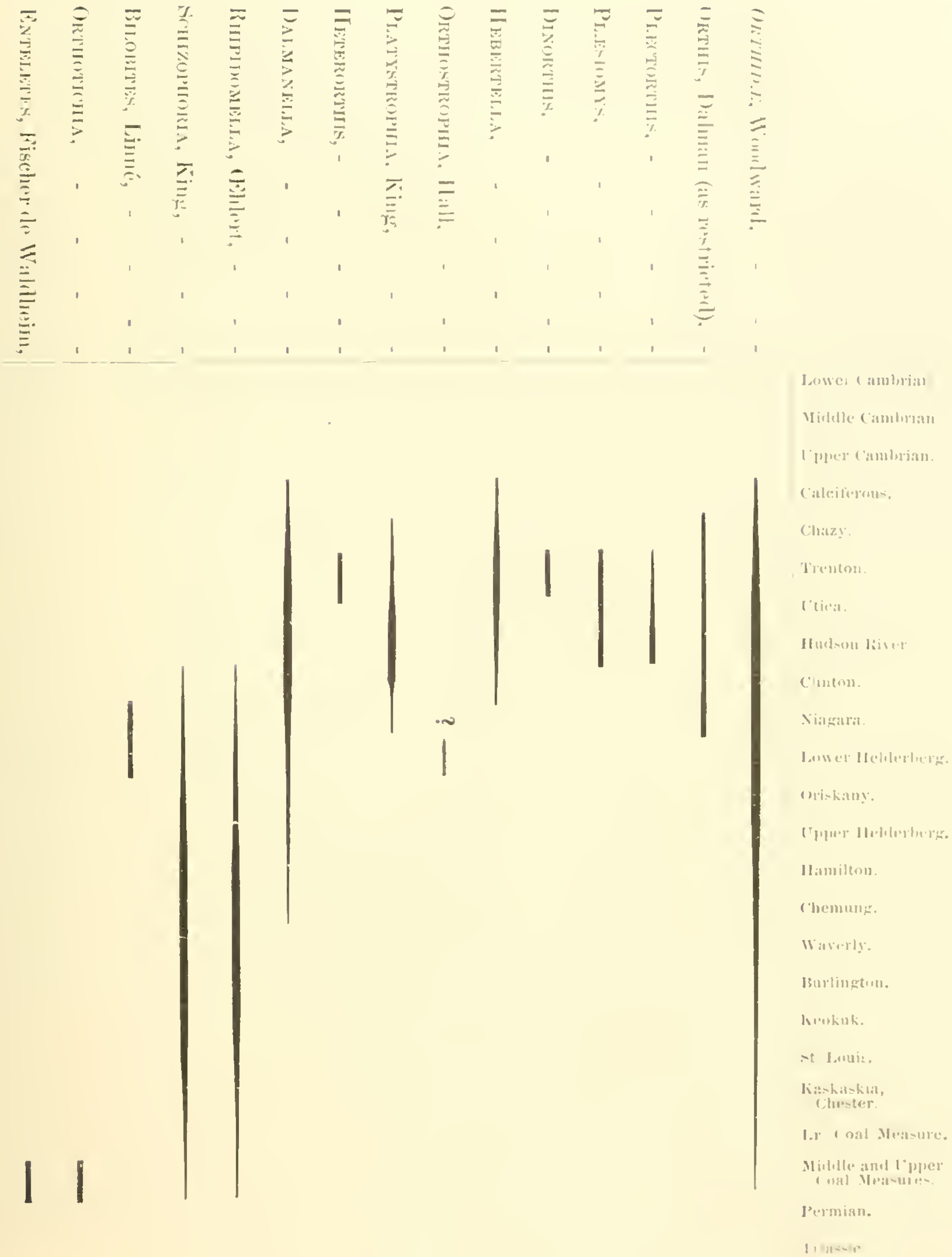
The following arrangement will indicate the relations of *Orthis flabellites* to the group of *Orthis callactis*, Dalman, and that of *Orthis pectinella*, Emmons:

ORTHIS, DALMAN (as restricted).

I. Group of ORTHIS CALLACTIS, Dalman.			
* O. costalis,	HALL	Chazy.	O. flabellites, HALL. Niagara.
* O. orthambonites,	BILLINGS	Quebec.	
* O. Euryone,	BILLINGS	Quebec.	
* O. Hippolyte.	BILLINGS	Quebec.	
* O. disparilis.	CONRAD	Trenton.	
* O. tricenaria.	CONRAD	Trenton and Hudson River.	
* O. Davidsoni,	DE VERNEUIL	Niagara.	
DINORTHIS.			
IV. Group of ORTHIS PECTINELLA, Emmons.			
* O. pectinella,	EMMONS	Trenton.	
* O. pectinella, var. semiovalis,	HALL	Trenton.	
* O. Sweeneyi.	N. H. WINCHELL,	Trenton.	

† Proceedings Boston Society Natural History, vol. xxiv, pp. 308–312. 1890.

The following tabular arrangement of the generic subdivisions of the ORTHIDÆ will show the geological range of each one of the subdivisions, and of the entire family:


ORTHIDÆ, Woodward,
ORTHIS, Dalman (as restricted),
PLECTORTHIS,
PLESIOMYS,
DINORTHIS,
HEBERTELLA,
ORTHOSTROPHIA, Hall,
PLATYSTROPHIA, King,
HETERORTHIS,
DALMANELLA,
RHIPIDOMELLA, Œhlert,
SCHIZOPHORIA, King,
BILOBITES, Linné,
ORTHOTICHIA,
ENTELETES, Fischer de Waldheim,
Lower Cambrian
Middle Cambrian
Upper Cambrian.
Calciferous.
Chazy.
Trenton.
Utica.
Hudson River
Clinton.
Niagara.
Lower Helderberg.
Oriskany.
Upper Helderberg.
Hamilton.
Chemung.
Waverly.
Burlington.
Keokuk.
St. Louis.
Kaskaskia, Chester.
Lr. Coal Measure.
Middle and Upper Coal Measures.
Permian.
Triassic
?

Genus BILLINGSELLA, gen. nov.

PLATE VIIA, FIGS. 1-9.

1857. *Orthis*, Billings. Report Geological Survey of Canada, p. 297.
1861. *Orthisina*, Billings. Geology of Vermont, vol. ii, p. 949, figs. 350–352.
1861. *Orthisina*, Billings. Palæozoic Fossils, vol. i, p. 10, figs. 11, 12.
1862. *Orthisina*, Billings. Palæozoic Fossils, vol. i, p. 138, fig. 115.
1863. *Orthis*, Hall. Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 134, pl. vi, figs. 23–27.
1863. *Orthisina*, Billings. Geology of Canada, p. 284, fig. 289.
1867. *Orthisina*, Hall. Trans. Albany Institute, vol. v, p. 113.
1882. *Orthis*, Whitfield. Geology of Wisconsin, vol. iv, p. 170, pl. i, figs. 4, 5.
1883. *Orthis* (*Orthisina?*), Hall. Report of State Geologist N. Y., pl. xxxvii, figs. 16–19.
1884. *Orthisina*, Whitfield. Bulletin Am. Museum Nat. Hist., vol. i. p. 144, pl. xiv. fig. 6.
1886. *Orthisina*, Walcott. Bulletin No. 30, U. S. Geol. Survey, pp. 120–122, pl. vii, figs. 5–7.

This term is proposed to include certain species, few in number, according to present knowledge, which have some decided external resemblance to Orthis and Clitambonites (=Orthisina), but which must be excluded from these genera on the basis of internal characters. The form taken as typical of this genus is *Orthis Pepina*, Hall, of the Potsdam sandstone of Wisconsin; other examples are *Orthisina festinata*, Billings, *O. orientalis*, Whitfield, and *O. transversa*, Walcott.

Diagnosis. Shell transverse; subquadrate or semicircular in outline. Contour concavo- or plano-convex. Surface sharply striate or plicate. Pedicle-valve the more convex; cardinal area moderately high, vertical or slightly incurved. Delthyrium covered by a convex plate, which, in rare instances, may be minutely perforated at the apex; the teeth are well developed, but the dental plates are continued along the bottom of the umbonal cavity, enclosing a small subelliptical muscular area near the apex. In the brachial valve the cardinal area is greatly inclined, making an obtuse angle with that of the opposite valve. The delthyrium is partially covered by a convex deltidium which never attains the development seen in the opposite valve, and is often wholly absent.

Type, *Orthis Pepina*, Hall. Potsdam sandstone.

Observations. From the foregoing description it is evident that the characters of this group are essentially orthoid. The shells are, however, all small and bear in common an expression unlike that of Orthis, while the presence of a highly developed arched deltidium is a feature showing positive

relationship to CLITAMBONITES, as does also the concave plate in the delthyrium of PROTORTHIS Like PROTORTHIS, this genus includes a series of primordial species antedating both ORTHIS and CLITAMBONITES, but apparently having attained about the same stage in the line of development toward these genera. To the species above mentioned may probably be added the *Streptorhynchus? primordiale*, Whitfield,* from the Calciferous beds at Fort Cassin, and *Orthisina grandæva*, Billings,† from the Chazy.

In the lower beds of the Upper Silurian of the Anticosti series occurs the *Orthis? laurentina*, Billings, a shell with the interior characters, and the exterior expression of *Orthis calligramma*, differing only in the presence of deltidia upon both valves, and in this respect resembling BILLINGSELLA and CLITAMBONITES.

GENUS PROTORTHIS, GEN. NOV.

PLATE VII A, FIGS. 14-21.

1868. *Orthis*, HARTT. Dawson's Acadian Geology, Second Edition, p. 644, fig. 233.
1884. *Orthis*, WALCOTT. Bulletin No. 10, U. S. Geological Survey, p. 17, pl. i, figs. 1, 1 a-d.
? 1884. *Orthis*, WALCOTT. Monogr. U. S. Geological Survey, vol. viii, p. 22, pl. ix, figs. 8, 8 a.
1886. *Orthis*, MATTHEW. Transactions Royal Society of Canada, Sec. IV, p. 43, pl. v, figs. 20 a-c; (?) p. 42, pl. v, figs. 18 a-c.

There is a small group of shells passing under the name of ORTHIS which should be separated from that genus, and given a new designation, since none of the existing generic groups can properly receive them. Their distinctive characters are as follows:

DIAGNOSIS. Shells small, transversely subquadrate or semicircular. Hinge-line straight, its length being equal to the greatest width of the valves. Valves unequally biconvex, or sub-planoconvex, the pedicle-valve being the larger. The cardinal area is narrow on both valves, but is higher on the pedicle-valve, and is transected by a broad delthyrium which is closed below by a concave plate apparently produced by the union of the dental lamellæ, which are not continued to the bottom of the valve; teeth distinctly developed. In the brachial valve the cardinal area also bears an open delthyrium: the dental

* Bulletin No. 8, American Museum of Natural History, p. 301, pl. xxiv, fig. 7. 1886.
† Canadian Naturalist and Geologist, vol. iv, p. 349. 1859.

sockets are obscure and the crural plates small; the latter appear to unite and form a low elevation across the base of the delthyrium. Cardinal process absent or rudimentary in all the specimens examined. Muscular markings in both valves extremely obscure.

Surface marked by distinct plications, with interstitial finer radii, which are crossed by delicate concentric striæ: these are usually accompanied by a low sinus and fold on the brachial and pedicle-valves, respectively; interior very finely papillose. Shell-substance fibrous and apparently punctate.

Type, *Orthis Billingsi*, Hartt. St. John group.

Mr. G. F. MATTHEW has kindly furnished an abundance of specimens for the study of *Orthis Billingsi*, Hartt,* and *Orthis Quacoensis*, Matthew,† from his Division 1 of the St. John group. These species are congeneric, and it is possible that Mr. WALCOTT'S‡ *Orthis Eurekensis*, from the Prospect Mountain group, Nevada, belongs to the same genus. It has already been observed that BILLINGS' species, *O. Mycale* and *O. Tritonia*, from the Lévis formation, are also without evidence of a cardinal process; but it is impossible to say whether they agree with *O. Billingsi* in other respects.

The characters of the St. John species are eminently comprehensive; first, the form of the shell is one more frequently met with among the strophomenids than among the orthids; the concave plate formed by the union of the dental lamellæ is never found in ORTHIS proper, though occurring in SCENIDIUM. In ORTHISINA or CLITAMBONITES this plate is always present, but always supported by a median septum and invariably accompanied by the convex deltidium, which, so far as known, does not exist in PROTORTHIS; while in the group typified by *Orthis Pepina*, Hall (here designated by the term BILLINGSELLA), the convex deltidium of CLITAMBONITES is present and the concave or dental plate absent. The apparent absence of a cardinal process in PROTORTHIS may be due to the imperfections of the fragile shells studied. The specimens of the

* HARTT, Dawson's Acadian Geology, Second Edition, p. 644, fig. 223. 1868. WALCOTT, Bulletin No 10, U. S. Geological Survey, p. 17, pl. i, figs. 1, 1 a–d. 1884.

† Illustrations of the Fauna of the St. John Group, No. 3. 1885. Trans. Royal Soc. Canada, Sec. IV, p. 43, pl. v, figs. 20 a–e. 1886.

‡ Palæontology of the Eureka District, p. 22, pl. xi, figs. 8, 8 a. 1884.

St. John shells are preserved as external and internal casts, and from some of these there is reason to infer that the substance of the shell was punctate. Mr. MATTHEW, in a private note, intimates that his *Kutorgina Latourensis*† may belong to the same group of shells. This species has been discussed in the preceding pages, under the genus KUTORGINA,‡ and although an examination of the more complete material received from Mr. MATTHEW, with his identification, has not proved entirely conclusive, there are reasons in favor of adopting the views of this author.

GENUS CLITAMBONITES, PANDER. 1830.

PLATE VII, FIGS. 23-28; AND PLATE XV A, FIGS. 1-8.

1822. *Anomites*, SCHLOTHEIM. Nachträge zur Petrefactenkunde, p. 65, pl. xiv, fig. 2.
1828. *Orthis (partim)*, DALMAN. Kongl. Svenska Vetenskaps-Akad. Handl. för 1827, p. 111, pl. ii, fig. 1.
1830. *Klitambonites*, PANDER. Beiträge zur Geognosie des russ. Reiches, p. 70, pl. iii, fig. 14; pl. xxviii, figs. 16, 17, 23, 24 (generic figures).
1830. *Pronites*, PANDER. Beiträge zur Geognosie des russ. Reiches, pp. 71-74, pl. xxviii, fig. 16 (generic figures); pls. xvi, xvii, xviii, xxiii, xxiv, xxvi.
1830. *Hemipronites*, PANDER. Beiträge zur Geognosie des russ. Reiches, pp. 74-76, pl. iii, fig. 14; pl. xxviii, fig. 18 (generic figures); pls. xvi B, xviii, xxii, xxiv.
1830. *Gonambonites*, PANDER. Beiträge zur Geognosie des russ. Reiches, pp. 77-80, pl. iii, fig. 1; pl. xxviii, fig. 15 (generic figures); pls. xv, xvi A, xvi B, xx, xxv.
1837. *Orthis*, VON BUCH. Abhandl. der k. Akad. Wissenschaft. Berlin, p. 63. 1836.
1840. *Orthis*, VON BUCH. Beiträge zur Bestimm. der Gebirgsformation Russlands, p. 20.
1840. *Orthis*, VON BUCH. Mem. Société Géologique de France, vol. iv, pp. 208-211.
1840. *Orthis*, VON EICHWALD. Urwelt Russlands, pt. i, p. 15.
1840. *Orthis*, VON EICHWALD. Ueber das Silur. Schichten-System von Estland, p. 148.
1842. *Orthis*, VON EICHWALD. Urwelt Russlands, pt. ii, p. 145, pl. iv, fig. 11.
1845. *Orthis*, DE VERNEUIL. Géol. de la Russie et de Mont. de l'Oural, pp. 198-206, pl. xii, figs. 1-4.
1846. *Clitambonites*, AGASSIZ. Nomenclator Zoologicus; Index Univer., p. 90.
1847. *Orthisina*, D'ORBIGNY. Comptes rendus, vol. xxv, p. 267.
1847. *Orthisina*, D'ORBIGNY. Ann. Science Nat., vol. viii, p. 268, pl. viii, fig. 7.
1850. *Orthisina*, D'ORBIGNY. Ann. Science Nat., vol. xiii, p. 319.
1850. *Orthisina*, D'ORBIGNY. Prodrome de Paléont. stratigraph. univ., p. 16.
1852. *Orthisina*, MCCOY. British Palæozoic Fossils, p. 231.
1853. *Orthisina (partim)*, DAVIDSON. Introd. British Fossil Brachiopoda, p. 104.
1859. *Orthis*, VON EICHWALD. Lethæa Rossica, vol. i, p. 838.
1865. *Orthisina*, SHALER. Bulletin No. 4, Museum Comparative Zoology, p. 67.
1871. *Orthisina*, DAVIDSON. British Silurian Brachiopoda, p. 278, pl. xlix, figs. 27-29.
1878. *Hemipronites*, WHITFIELD. Ann. Rept. Geol. Survey of Wisconsin, for 1877, p. 72.
1882. *Hemipronites*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 243, pl. x, figs. 15-17.
1883. *Orthisina*, DAVIDSON. British Silurian Brachiopoda; Suppl. p. 175, pl. xvi, figs. 16-18.
1887. *Clitambonites*, ŒHLERT. Fischer's Manuel de Conchyl: Brachiopoda, p. 1289.

* Illustrations of the Fauna of the St. John Group, p. 42, pl. v, figs. 18 a-e.

† See page 93, plate iv, figs. 18-20.

Diagnosis. Shells with a subsemicircular marginal outline; convex or subpyramidal in the typical group. Hinge-line straight, and forming the greatest diameter of the shell. Pedicle-valve elevated, cardinal area high, vertical, or sometimes incurved, and crossed by a broad delthyrium, which is normally covered by a convex, perforate deltidium. On the interior of the valve the dental lamellæ are very strongly developed, converging and uniting in the median line before reaching the bottom of the valve; thus forming a *spondylium*,* which with the deltidium encloses a conical subrostral vault. This plate is supported by a median septum extending for about one-half the length of the valve. Muscular impressions obscure. In the brachial valve, the cardinal area is considerably developed, and the delthyrium filled by a conspicuous callosity, against the inner side of which the simple orthoid cardinal process abuts. The dental sockets are large, the crural plates low and continuous with the edges of the delthyrial callosity. A thickened transverse area is formed in the umbonal region by the union of the inner portions of the crural plates with the cardinal process, and thence a broad median ridge is continued forward through the muscular area, which is sharply defined and quadripartite. External surface covered with radiating striæ. Shell-substance impunctate.

Type, *Pronites adscendens*, Pander. Lower Silurian.

American example, *Orthisina Verneuili*, von Eichwald. Trenton limestone.

Observations. Although d'Orbigny's term, Orthisina, has found its way into general use for this group of shells, there is no reason why it should replace the name Clitambonites, a genus clearly defined and abundantly illustrated by its author. In order to show Pander's conception of this group, and since his "Beiträge zur Geognosie des russischen Reiches" is a work not generally accessible to American students, his original descriptions and typical figures are here introduced.†

* Σπονδύλιον, *vertebra*. This term will apply with equal propriety to the similar plate existing in the pedicle-valve of other brachiopods, *e. g.*, Clitambonites, Pentamerus, Camarella, Stenoschisma, etc.

† Pander's determinations of genera and species of brachiopoda evince a remarkable insight and analytical power. He was in this regard a generation in advance of his contemporaries, who apparently felt it their duty to throw both his genera and species back into the old groups whence they were derived, and thus totally ignore his work. The inaccessibility of Pander's works to western students, has been one great cause of the misunderstanding of many brachiopodous genera.

"Klitambonites. Die Schlossfläche der oberen Schale bildet ein vollkommenes Dreieck, dessen Grundfläche an der Berührungsstelle derselben mit der unteren Schale sich befindet, und dessen Spitze schräg oder gerade nach oben gegen die Oberfläche hinaufsteigt. In der Mitte dieses grosseren Dreiecks findet sich noch ein kleineres, das gewölbt nach aussen hervortritt und das wir, in so fern es von aussen die zum Schlosse gehörigen Theile beschützt, mit dem Namen des Schlossdeckels belegen wollen. Die Schlossfläche der unteren Schale ist fast geradlinig, ragt etwas nach aussen hervor und bildet in der Mitte einen Wulst, zwischen welchem und dem Schlossdeckel die bald sichelförmige, bald dreieckige Oeffnung zum Durchgange des fleischigen Stieles sich befindet. Die vier Seiten der Schalen sind hier am deutlichsten ausgesprochen, die Oberflächen sind wenig gewölbt, gewöhnlich verläuft die der oberen Schale von der Spitze der Schlossfläche, welche häufig den höchsten Punkt bildet, schräg nach vorn und gegen die Seiten sich abflächend fort. Der Queerdurchmesser ist gewöhnlich der vorwaltende.

"Die feinen Längsrippen werden durch concentrische, unter einander und mit der Brust und der Seitenlinien parallel laufende, Streifen unterbrochen, so dass erstere treppenartig, selbst etwas dachziegelartig auf einander zu liegen kommen. Die Brustlinie ist in der Queere im Allgemeinen gerade, selten und auch dann nur unbedeutend gegen die Oberschale sich hinaufbeugend. Da aber hier doch sehr grosse Verschiedenheiten sowohl in Rücksicht der Wölbung, als der Durchmesser und der Höhe der Schlossfläche vorkommen, so wird es bequemer sein, die Klitamboniten noch in zwei Abtheilungen zu trennen, welche sich hauptsächlich dadurch unterscheiden, dass bei den einen, die wir Proniten nennen, die obere Spitze des Dreiecks der Schlossfläche den höchsten Punkt in der Schale erreicht, während bei den Hemiproniten letztere zwischen der Rückenfläche und der Brustlinie fällt, erstere also niedriger ist."*

Figs. 1, 2, 3. *Pronites adscendens.* After Pander.

* "The cardinal area of the upper valve forms a complete triangle, whose base is the line of junction of the valves and whose apex is either inclined or direct. In the center of this large triangle is a smaller one, which is arched outward, and inasmuch as this protects the parts belonging to the hinge, we shall term it the Hinge-cover. The cardinal area of the lower valve is almost straight and somewhat elevated and outwardly inclined; in the center is a swelling, between which and the hinge-cover is the sometimes sickle-

It was evidently the intention of the author to make not only these two divisions PRONITES and HEMIPRONITES of the genus KLITAMBONITES, but also to include as of coequal value the divisions GONAMBONITES, ORTHAMBONITES and PLECTAMBONITES; and the principal differences in these divisions, as based on the varying inclination of the cardinal area, are expressed in the following figures taken from Plate 28 of his work.

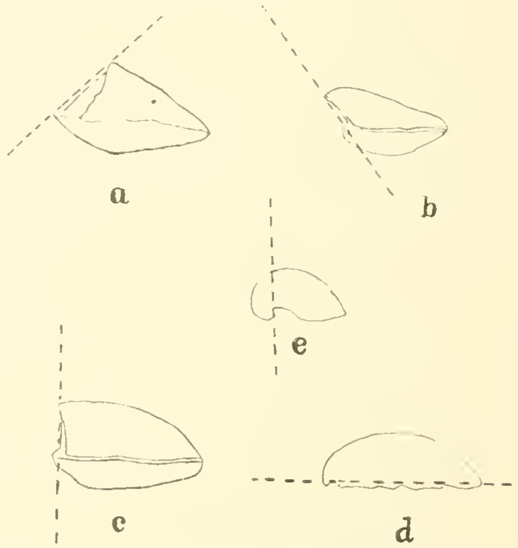


FIG. 1. *a*, CLITAMBONITES, *b*, GONAMBONITES; *c*, CLITAMBONITES; *d*, ORTHAMBONITES; *e*, PLECTAMBONITES. After PANDER.

ORTHAMBONITES is undoubtedly precisely synonymous with ORTHIS, Dalman. PLECTAMBONITES is manifestly a good genus, equivalent to LEPTÆNA of authors, not of DALMAN. DALL has called attention* to the fact that PANDER, in subdividing the entire group of CLITAMBONITES, left no type-species upon which the

shaped, sometimes triangular opening for the passage of the fleshy pedicle. The four sides of the shells are most clearly pronounced; the surfaces are slightly arched, that of the upper valve usually sloping from the apex of the cardinal area, which is generally the highest point, rather abruptly forward, and more gently toward the sides. The transverse diameter is usually the greatest.

"The fine longitudinal ribs are interrupted by concentric lines, parallel to one another and to the anterior and lateral margins; thus the former lie on one another like steps or roof-tiles. The anterior margin is, in general, straight, rarely, and then but inconsiderably, bending toward the upper valves. As, however, there are great differences both in convexity and in the diameter and height of the cardinal area, it will be more convenient to separate the Klitambonites into two divisions, which are distinguished principally by the fact that in one, which we term Pronites, the upper angle of the triangular cardinal area reaches the highest point in the shell, while in the Hemipronites, the last lies between the posterior and anterior margins, and the cardinal area is therefore lower."

* Bulletin No. 8, U. S. National Museum, p. 39. 1877.

application of this term can be based. It is therefore necessary to take the first species of the typical subgenus PRONITES* (*Pronites adscendens*) as the type of CLITAMBONITES; and it will probably prove desirable to limit the application of this term pretty nearly to the typical division included by PANDER under

FIGS. 5, 6. *Orthambonites transversa.* After PANDER.

PRONITES; that is, to shells having the lower valve flat, the upper valve with the greatest elevation at the beak, the greatest width of the shell along the hinge, and the cardinal area vertical. It will probably be unwise to attempt to maintain the term GONAMBONITES for forms similar in all respects to CLITAMBONITES except in having a backward inclination of the cardinal area.

With the foregoing definition of CLITAMBONITES, D'ORBIGNY'S ORTHISINA is apparently a synonym. The name was proposed in the *Comptes Rendus*, in 1847, but no example was cited. It was again used in the same year in the *Annales des Sciences Naturelles*, and accompanied by a figure without specific name. In 1850 it was used in a later volume of the same work, without the specification of a type,

FIGS. 7, 8. *Gonambonites lata* After PANDER.

but with mention of three species: (1) *O. anomala*, Schlotheim; (2) *O. adscendens*, Pander; (3) *O. Verneuili*, von Eichwald; and in the same year the name is again defined in his *Prodrome de Paléontologie Stratigraphique*, etc., with the species cited in the following order: (1) *O. Verneuili*, (2) *O. anomala*, (3) *O. adscendens*. *O. Verneuili*, if taken as the type of this group, presents a species in all generic features identical with *Clitambonites adscendens*. Should, however, *O. anomala* be regarded as the typical species of ORTHISINA, it may eventually be desirable to

* It appears that PRONITES was also a preoccupied term, having been used by ILLIGER for a genus of birds, in 1811.

accord the term a subordinate value on the basis of the extravagantly developed cardinal area in the brachial valve. (See Plate VII, figs. 25, 26.)

HEMIPRONITES. The type of structure exemplified by this group is distinct in many important respects from that of *Pronites* (*Clitambonites*) *adscendens*. The valves are subequally convex, the hinge-line shorter than the greatest diameter of the shell, the greatest depth of the pedicle-valve is not at the apex; the deltidium is apparently not perforated, and the surface is covered by extremely fine radiating striæ. Regarding *Hemipronites tumida* as the type, the association of species will represent a very well defined group, which may provisionally be held as of subordinate value to CLITAMBONITES, but which when better known may have to be more definitely separated from that genus. Its interior characters, other than the dental trough supported by a median septum, are not well understood.*

FIGS. 9, 10. *Hemipronites tumida*
After PANDER.

The features of CLITAMBONITES are very strongly orthoid. This is seen to best advantage in the brachial valve, where the difference from the interior of *O. calligramma* rests principally on the modifications produced by the deltidium. The *Orthis? laurentina* of BILLINGS, from the Anticosti group, or Middle Silurian, is in every respect an intermediate form between *Orthis calligramma* and CLITAMBONITES. In BILLINGSELLA the dental plates do not unite, though the delthyrium is completely covered in the pedicle-valve and partially so in the brachial valve. The earliest appearance of these features is in the primordial species of PROTORTHIS and BILLINGSELLA, the former genus being, so far as known, without a convex deltidium but having the concave dental trough or spondylium developed, though unsupported by a median septum. In the genus POLYTŒCHIA is the earliest known combination of these two features,

* It is evident that PANDER did not regard this first species in his list as a thoroughly normal example of the group. He says (p. 74): "Schon durch *Pr. oblonga* und *humilis* sahen wir, dass ein Uebergang zu den Hemiproniten Statt fand, ein anderer geschieht durch *Hemipronites tumida*, bei welchem die Rückenfläche noch ziemlich hoch hinaufragt, allein nicht mehr die höchste Spitze der Oberschale bildet, letztere wölbt sich schon vollkommen, und der äussere Ansehen ist doch noch das eines Proniten." Probably a more typical example of his twenty-one species would be *H. alta*, pl. xxiii, fig. 6, or *H. sphærica*, fig. 7. DE VERNEUIL, in the Géologie de la Russie, etc., p. 205, referred nineteen of these species to the *Orthis hemipronites* of VON BUCH, 1840, a name which of course has no value if founded on any of PANDER's species.

and the formation of an umbonal or subrostral vault supported by a median septum.

The geological range of both Clitambonites and Hemipronites is limited to the Lower Silurian. In American faunas the latter group is still unknown, and the former is represented by only two species, *Orthisina Verneuili* (von Eichwald), Billings, from the Trenton limestone and the Anticosti fauna, and *Hemipronites Americana*, Whitfield, a closely allied species, from the Galena horizon of the Trenton, in Wisconsin.

Polytœchia, sub-gen. nov. Plate vii a, figs. 26–30.

1886. *Hemipronites*, Whitfield. Bulletin American Museum of Natural History, vol. i, No. 8, p. 300, pl. xxiv, figs. 1–5.

This name is proposed for the species *Hemipronites apicalis*, Whitfield, the essential characters of which have been clearly demonstrated by that author.* Mr. Whitfield recognized the distinctive character of this fossil but hesitated to propose a new generic term, which circumstances now require.

Fig. 11. *Polytœchia apicalis.*
Transverse section of pedicle-valve, near the apex.

Fig. 12. *Polytœchia apicalis.*
Transverse section near the cardinal margin.

Diagnosis. Shell small, subtrihedral in contour. Hinge-line straight, about equaling the diameter of the shell. Pedicle-valve with a high, nearly vertical cardinal area marked with oblique striations parallel to the lateral margins.

* In a provisional list of the genera of palæozoic brachiopoda, published in the Eighth Annual Report of the State Geologist (p. 44, 1889), the name Waagenia was used with the intention of applying it to this sub-genus, but it appears that both Waagenia and Waagenella are preoccupied terms, therefore precluding this intended expression of esteem and appreciation for the invaluable services of Dr. Waagen in this department of science.

Delthyrium covered by a narrow, convex plate; the presence of a foramen not determined. On the interior the dental lamellæ are widely separated, and descend along the umbonal cavity for a short distance vertically, thence bending sharply inward and meeting at a low angle in the median line; thus forming, with the deltidium, a conspicuous subrostral vault. This inner spoon-shaped plate, spondylium, is supported by a stout median septum, and two smaller lateral septa, which meet it at the lines of angulation; the former of these extends for the entire length of the plate, while the latter is free from the accessory septa near its anterior edge. The umbonal cavity of the valve is thus divided into five chambers, and in the lateral chambers there is still another septum, lower than the rest and not extending to the spondylium. The brachial valve is shallow and depressed-convex, with a narrow cardinal area. The delthyrium is very broad with a partially developed covering, the dental sockets are widely separated, the crural plates narrow and nearly parallel to the hinge-line The cardinal process is simple, linear and quite prominent, and at its union with the crural plates is a subtriangular thickening which is supported by a low median septum. Surface covered with fine, elevated, radiating striæ, without evidence of median fold and sinus.

Type, *Hemipronites apicalis*, Whitfield (not *Orthis? apicalis*, Billings). Calciferous beds.

The closest relations of this sub-genus are with CLITAMBONITES (= ORTHISINA), being chiefly distinguished by the multipartite umbonal cavity of the pedicle-valve. The typical species is from the fauna of the Calciferous sandstone of Fort Cassin, Vermont. With this species Mr. WHITFIELD compares the *Orthis? apicalis* of BILLINGS, from the "Quebec group" (Point Lévis Limestone, No. 1),* but after examining the original specimens of both species, and with considerable additional material from Fort Cassin, there can be no hesitation in pronouncing the two forms as quite distinct, not only in internal structure, but also in external characters.

* Palaeozoic Fossils, p. 331, fig. 291 a.

Genus SCENIDIUM,* Hall. 1860.

PLATE VII A, FIGS. 31-43.

1846. *Orthis*, Rouault. Bulletin Soc. Géologique de France, 2nd Ser., tome iv, p. 322.
1848. *Orthis*, Davidson. Bulletin Soc. Géologique de France, 2nd Ser., tome v, p. 323.
1852. *Orthis*, Hall. Palæontology of N. Y., vol. ii, p. 251, pl. li, fig. 2.
1853. *Orthis*, Schnur. Zusammenst. und Beschreib. Eifel Brachiopoden.
1859. *Orthis*, Salter. Murchison's Siluria, p. 544.
1859. *Orthis*, Hall. Palæontology of N. Y., vol. iii, p. 173.
1860. *Orthis*, Lindström. Gotland's Brachiopoder, p. 370.
1860. *Skenidium*, Hall. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 70, figs. 1-5.
1861. *Skenidium* (*Orthis*), Hall. Palæontology of N. Y., vol. iii, pl. x A, figs. 13-15.
1868. *Orthis*, Davidson. Trans. Geological Society of Glasgow.
1869. *Skenidium*, Safford. Geology of Tennessee, p. 287.
1869. *Orthis*, Davidson. British Silurian Brachiopoda, p. 208, pl. xxv, figs. 4, 9.
1871. *Orthis*, Davidson. British Silurian Brachiopoda, p. 254, pl. xxxviii, fig. 26.
1871. *Orthis*, Quenstedt. Petrefactenkunde Deutschlands.
1871. *Mystrophora*, Kayser. Zeitschr. der deutsch. geolog. Gesellschaft, p. 612, pl. xiii, fig. 5.
1872. *Orthis*, Rigaux. Bulletin Société Academ. de Boulogne.
1882. *Skenidium*, Davidson. British Devonian Brachiopoda. Suppl., p. 49, pl. iii, figs. 11-14.
1883. *Skenidium*, Davidson. British Silurian Brachiopoda. Suppl., pp. 173-175, pl. xi, figs. 1-7.
1883. *Skenidium*, Hall. Report of N. Y. State Geologist for 1882, pl. xxxvii, figs. 29-35.
(?) 1884. *Skenidium*, Walcott. Palæontology of Eureka District, p. 116, pl. xiii, fig. 4.
1887. *Scenidium*, Œhlert. Bull. Société d'Etudes Scientifiques d'Angers, extr., p. 4, pl. v, figs. 8-10.
1887. *Skenidium*, Tschernyschew. Memoires Comité Geologique, vol. iii, No. 3, pp. 106, 107, pl. iv, figs. 13-17.

Diagnosis. "Shell subpyramidal, somewhat semicircular, with or without median sinus and elevation. Area large, triangular, divided by a narrow fissure, which is sometimes closed at the summit by a concave deltidium. Valves articulating by teeth and sockets, which are often obscure or obsolete. Dorsal valve flat, or varying from depressed-convex to concave. Beak entire, or indented by the foramen; cardinal line straight and usually equaling the width of the shell; cardinal plates broad and well developed, marked by the imprints of the peduncular muscles, and produced in the middle in a pointed process; the cardinal process extends, as a median septum, through the length of the shell, and may be simple or divided at its [anterior] extremity. Ventral valve elevated, subpyramidal; beak straight or slightly arched; muscular impressions undetermined. Exterior surface covered with radiating striæ."—Hall, 1860, *ut. cit.*

Type, *Orthis insignis*, Hall. Lower Helderberg group.

* The customary spelling of this generic term has been *Skenidium*; the better form is undoubtedly Scenidium, as suggested by Dr. Œhlert.

OBSERVATIONS. The shells of this genus are all small, and the high, usually erect cardinal areas give them a distinct cyrtiniform aspect. Their essential characters are, however, very positively orthoid. In the typical forms of ORTHIS following the structure of *O. calligramma*, there is, first the pyramidal form of the shell, less pronounced indeed than in SCENIDIUM; then, on the interior of the brachial valve, a general thickening and elevation of the deltidial region as illustrated in Plate V, fig. 14. This thickening ends abruptly below the crural plates, and at the base of the narrow, simple, cardinal process, but a low median ridge is continued forward until it is merged into the radial plications of the shell. In the species described by Mr. BILLINGS as *O. Merope*, from the Trenton limestone,* and a very closely allied, probably identical form from the Hudson River horizon at Cincinnati (in both of which the size and form is that of SCENIDIUM), the interior features of the brachial valve are precisely of this character, and the shell evinces no progress from ORTHIS toward SCENIDIUM except in its interior. A pronounced advance in these respects is seen in *Scenidium Halli*, Safford, from the Trenton horizon of Minnesota and Tennessee; here the deltidial area is more distinctly elevated and the median septum low, but sharply defined. In *Scenidium pyramidale*, Hall, of the Niagara, an abundant shell at Lockport, N. Y., and *S. Lewisi*, Davidson, of the Wenlock of England and Gotland, the septum of the brachial valve is higher, though not attaining so great a development as in the Lower Helderberg species, *S. insigne*, where it extends for a considerable distance into the cavity of the pedicle-valve, virtually dividing it into two chambers.

The extreme development of these characters is attained in *Scenidium areola*, Quenstedt (sp.), from the middle Devonian of the Eifel† and Torquay.‡ Here the cardinal platform is wholly separated from the bottom of the valve, and is supported by the median septum, the latter being a high vertical partition extending to the opposite valve and leaving only its subrostral cavity undivided.

* Palæozoic Fossils, vol. i, p. 139. 1862.

† KAYSER, Zeitschr. der deutsch. Geol. Gesellschaft, vol. 23, p. 612, pl. xiii, fig. 5. 1871.

‡ DAVIDSON, British Devonian Brachiopoda. Suppl., p. 49. 1882.

The gradual development of the characters of Scenidium can be traced from the typical features of Orthis, and, after attaining its extreme manifestation in the Devonian, this combination abruptly disappeared, and no further representatives in this line have been discovered.

The incurved plate in the rostrum of the pedicle-valve, which in the original diagnosis was regarded as a deltidium, appears to be due to the union of the dental lamellæ, forming a spondylium analogous to that in Clitambonites.

The shell-substance of Scenidium is very finely fibrous, and from sections of *S. pyramidale* appears to be impunctate. Mr. Davidson, however, has represented* an enlargement of the surface of *S. areola*, which shows superficial granulations or pits which may be evidence of punctate structure. According to present knowledge Scenidium appeared in the fauna of the Trenton group, and has had a wide distribution, disappearing in the Devonian.

Besides the American species already mentioned, Mr. Walcott has described *S. devonicum*, from the Lower Devonian horizon of the Eureka District, Nevada. *Scenidium Lewisi*, Davidson, occurs in the Wenlock of England, Scotland and the Isle of Gotland; *S. Lewisi*, var. *Woodlandense*, Davidson, in the Middle Llandovery of Ayrshire; *S. Lewisi*, var. *Hughesi*, Davidson, in the Coniston grits; *S. Shallockense*, Davidson, and *S. Grayiæ*, Davidson, in the Middle Caradoc of Girvan.† Mr. Davidson has also referred to this genus the *Orthis Deshayesi*, Bouchard, occurring in the Devonian beds of Ferques, Brittany;‡ and Œhlert describes *Scenidium Baylii* (= *Orthis Baylii*, Rouault), from the Devonian of Gahard, in the west of France.§ Two other Devonian species have been described by Tschernyschew,‖ from the Stringocephalus-beds of the Urals, viz., *S. Mœlleri* and *S. Uralicum*.

* British Devonian Brachiopoda. Suppl., pl. iii, fig. 11 c.

† See Davidson, British Silurian Brachiopoda. Suppl., pp. 173–175. 1883.

‡ See Davidson, British Devonian Brachiopoda. Suppl., p. 50. 1881; and Rigaux, Bull. de la Société Academique de Boulogne, vol. i. 1872.

§ Brachiopodes du Devonien de l'ouest de la France, p. 4. 1887.

‖ Die Fauna des mittleren und oberen Devon am West-Abhange des Urals, pp. 106, 107.

GENUS ORTHIDIUM, GEN. NOV.

PLATE VII A, FIGS. 22-25.

1862. *Orthis*, BILLINGS. Palæozoic Fossils, vol. i, p. 75, figs. 8, a, b, c.

DIAGNOSIS. Shell very small, transverse, having the external aspect of SCENIDIUM. Hinge-line long, making the greatest diameter of the shell. Pedicle-valve the more convex; cardinal area moderately high, with a broad open delthyrium, strong teeth and inconspicuous dental plates, in all respects like the corresponding valve of *Orthis calligramma*. Brachial valve slightly convex; cardinal area very narrow; dental sockets well developed, crural plates very short and erect, coalesced with the cardinal process, which thus becomes a vertical, transverse, subcrescentic plate, at the base of which the shell is somewhat excavated; muscular scar quadruplicate. Surface covered with radiating striæ, which extend over the broad, low sinus and fold in the brachial and pedicle-valves respectively. In the former the sinus makes a prominent median ridge in the interior of the valve. Shell-structure not determined.

Type, *Orthis gemmicula*, Billings. Quebec group.

OBSERVATIONS. This interesting fossil presents the earliest known phase of the development of the cardinal process which characterizes STROPHOMENA, and the other streptorhynchoid genera; and it is upon this feature that its separation as a distinct genus is rendered necessary. All the features of the pedicle-valve are strictly orthoid.

On the brachial valve the cardinal process instead of being bipartite at its crest, and grooved or multipartite on its posterior face, is simple, terminating in a rounded apex and filling the delthyrium.

These features are beautifully shown in Mr. BILLINGS' original specimens of *Orthis gemmicula*, which have been kindly loaned by the Director of the Geological Survey of Canada, through Mr. J. F WHITEAVES, for the purpose of illustration in this volume. No other species referable to the same genus is at present known. *Orthis gemmicula* is from the Quebec group, at Point Lévis, "in the upper part of Limestone No. 2" (BILLINGS).

GENUS STROPHOMENA, RAFINESQUE (DE BLAINVILLE). 1825.

PLATE IX, FIGS. 1-20; PLATE IX A FIGS. 3, 5-18; AND PLATE XI A, FIGS. 1-8.

1820. *Strophomenes*, RAFINESQUE. Annales Gen. Sci. phys. Bruxelles, tom. v, p. 232.
1824. *Strophomenes*, DEFRANCE. Tableau des Corps organisés fossiles, p. 6.
1825. *Strophomena*, DE BLAINVILLE. Manuel de Malacologie et Conchyliologie, vol. i. p. 513, pl. liii, figs. 2, 2a.
1827. *Strophomenes*, DEFRANCE. Dictionnaire des Sciences Naturelles, vol. li, p. 151, and Atlas.
1831. *Strophomenes*, RAFINESQUE. Descr. Remarkable Objects in Cabinet of Prof. RAFINESQUE, p. 4.
1839. *Orthis*, J. DE C. SOWERBY. Murchison's Silurian System, pl. xiii, fig. 13; pl. xx, fig. 13.
1844. *Strophomena*, OWEN. Geological Expl. of Iowa, Wisconsin, and Illinois, p. 70, pl. 17, fig. 2.
1847. *Leptœna*, HALL. Palæontology N. Y., vol. i, pp. 111-115, pl. xxxi B, figs. 3, 4, 7, 9.
1847. *Leptœna*, DAVIDSON. London Geological Journal, vol. i, p. 59, pl. xii, figs. 22-24.
1847. *Orthis*, DAVIDSON. London Geological Journal, vol. i, p. 62, pl. xiii, figs. 14, 15, 25.
1848. *Leptœna*, DAVIDSON. Bull. Société Géologique France, Ser. 2, vol. v, p. 319, pl. ii, fig. 11.
1848. *Strophomena*, D'ORBIGNY. Bull. Société Géologique France, Ser. 2, vol. v, p. 336.
1848. *Leptœna*, DE VERNEUIL. Bull. Société Géologique France, Ser. 2, vol. v, p. 350.
1848. *Leptœna*, PHILLIPS and SALTER. Mem. Geol. Survey of Great Britain, p. 283.
1850. *Strophomena*, KING. Monogr. Permian Fossils of England, p. 103.
1852. *Orthis*, McCOY. Synopsis Silurian Fossils Ireland, p. 31.
1852. *Leptœna* (*Strophomena*), McCOY. British Palæozoic Fossils, pp. 241, 244.
1855. *Strophomena*, EMMONS. American Geology, vol. i, p. 199, fig. 61.
1856. *Strophomena*, BILLINGS. Canadian Naturalist and Geologist, vol. i, p. 203, figs. 1, 2.
1859. *Strophomena*, SALTER Murchison's Siluria, Third Edition, pl. xx, fig. 18.
1859. *Leptœna*, VON EICHWALD. Lethæa rossica, vol. i, p. 864.
1859. *Strophomena*, HALL. Twelfth Rept. N. Y. State Cab. Nat. Hist., p. 70.
1860. *Strophomena*, LINDSTRÖM. Öfvers. af Kong. Vetenskaps-Akad. Förhandl., vol. xvii, p. 372.
1860. *Strophomena*, BILLINGS. Canadian Naturalist and Geologist, vol. v, pp. 57, 60, figs. 6, 7.
1862. *Strophomena*, BILLINGS. Palæozoic Fossils, vol. i, pp. 123-127, figs. 102-104; pp. 129, 132, figs. 107, 109.
1862. *Strophomena*, HALL. Annual Report Geological Survey of Wisconsin, p. 54, fig. 7.
1863. *Strophomena*, BILLINGS. Geology of Canada; Report of Progress, p. 164, figs. 142, 143; p. 209, figs. 206, 207.
1868. *Strophomena*, DAVIDSON. Trans. Geol. Soc. Glasgow, Pal. Ser., vol. i, p. 17, pl. ii, figs. 21-23.
1871. *Strophomena*, JAMES. Catalogue Lower Silurian Foss. Cincinnati group, p. 9.
1871. *Orthis*, QUENSTEDT. Petrefactenk. Deutschlands; Brachiopoden, pp. 575, 576, pl. 56, figs. 27-33.
1871. *Strophomena*, DAVIDSON. British Silurian Brachiopoda, p. 299, pl. xliv, figs. 2-13, 21, 22; p. 311, pl. xlvi, figs. 1-3, 5, 6.
1873. *Hemipronites* (*Strophomena*), MEEK. Palæontology of Ohio, vol. i, pp. 77-88, pl. v, figs. 4, 5; pl. vi, figs. 1-5.
1874. *Streptorhynchus*, MILLER. Cincinnati Quarterly Journal of Science, vol. i, p. 148, figs. 14-16.
1874. *Streptorhynchus*, JAMES. Cincinnati Quarterly Journal of Science, vol. i, pp. 240, 241.
1875. *Hemipronites*, MILLER. Cincinnati Quarterly Journal of Science, vol. ii, pp. 41-49, fig. 5 and p. 50.
1875. *Strophomena*, HALL and WHITFIELD. Palæontology of Ohio, vol. ii, p. 115, pl. v, fig. 10.
1875. *Strophomena*, WHITE. Geographical and Geological Exploration West 100th Meridian, p. 69, pl. iv, fig. 8.
1880. *Streptorhynchus*, WHITFIELD. Annual Report Geological Survey of Wisconsin, p. 61.
1881. *Streptorhynchus*, JAMES. The Palæontologist, No. 5, pp. 41, 43.
1881. *Strophomena*, WHITE. Tenth Rept. Indiana State Geologist, p. 115, pl. ii, figs. 13, 14.

1882. *Streptorhynchus*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 261, pl. xii, figs. 9, 10; p. 263, pl. xii, figs. 11-13.
1883. *Strophomena*, DAVIDSON. British Silurian Brachiopóda, Supplement, p. 192, pl. xi. figs. 20, 21; pl. xii, fig. 30; pl. xvi, fig. 8.
1883. *Streptorhynchus*, HALL. Second Ann. Rept. State Geologist N. Y., Expl., pl. xxxix, figs. 1-9, 15-30; pl. xlii, figs. 10-15.
1884. *Streptorhynchus*, WALCOTT. Palæontology Eureka District, p. 75, pl. xi, fig. 9.
1887. *Strophomena*, SHALER Memoirs Kentucky Geological Survey, p. 13, plates 4 and 5.

Probably no generic term among the brachiopoda has given rise to a greater diversity of expression of opinion among authors as to its value and application. In order to appreciate the inapplicability of the term as now current among the American and European writers, a brief *résumé* of its history becomes necessary.

In 1820, C. S. RAFINESQUE made use of the term STROPHOMENES in the Annales Générales des Sciences Physiques de Bruxelles, vol. v, p. 232.* This name was not accompanied either by a diagnosis or the citation of any species. The author, after speaking of the difficulties experienced in working out certain groups, says:

"Par exemple, parmi les térébratules, nous en avons observé plus de 60 espèces, que nous avons dû ranger sous plusieurs nouveaux genres, tels que *gonotrema*, *dictionia*, *diclisma*, *pleurinia*, *stropheria*, *strophomenes*, *clipsilis*, etc., outre les vrais genres *terebratula* et *productus*. Le seul *G. gonotrema*, qui comprend les térébratules a ouverture anguleuse allongée et a charnière tronquée, etc., contient plus de 30 espèces."

The term STROPHOMENES, Rafinesque, was afterwards used by DEFRANCE, in 1824, also without definition, in the "Tableau des Corps Organisés Fossiles," p. 6. In 1825, DE BLAINVILLE† made use of the term STROPHOMENA, in the following manner:

"STROPHOMÈNE. *Strophomena.*—Animal tout-a-fait inconnu. Coquille régulière symetrique, équilaterale, subéquivalve; une valve plate et l'autre un peu excavée: articulation droite, transverse, offrant a droit et à gauche d'une

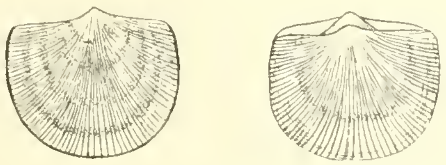
* This paper does not appear in the "Complete Writings of Constantine Smaltz Rafinesque on Recent and Fossil Conchology," edited by WILLIAM G. BINNEY and GEORGE W. TRYON, JR. 1864. As the original paper has not been accessible, we are under obligations to Dr. H. A. PILSBY, of the Conchological Section of the Philadelphia Academy of Natural Science, for communicating the quotation given.

† Manuel de Malacologie et Conchyliologie, vol. i, p. 513, pl. liii, figs. 2, 2a.

subéchancrure mediane, un bourrelet peu considérable, crénelé ou dentelé transversalement ; aucun indice de support.

"Ex. La *Strophomène rugueuse*, *Strophomena rugosa*, Rafin., pl. liii, fig. 2.

"*Observ.* Ce genre, proposé par M. Rafinesque, ne contient encore que des espèces fossiles, au nombre de trois, suivant M. Defrance."



Figs. 13, 14. *Strophomena rugosa* After de Blainville.

The original figures accompanying this description are here reproduced. A similar description of the genus, with a more extended notice of the species *S. rugosa*, was given in 1827, in the "Dictionnaire des Sciences Naturelles," vol. li, p. 151.* In this place the form of the generic term is invariably Strophomenes, and the description is in the following language:

"Strophomène rugueuse; *Strophomenes rugosa*, Rafinesque. Coquille bombée en dessous, et dont la valve supérieure est un peu concave et chargée de petites stries rayonnantes. Largeur, un pouce. Fossile de l'Amérique septentrionale. On voit une figure d'une coquille de cette espèce dans l'atlas de ce Dictionnaire, planche des fossiles. Des coquilles de ce genre, qu'on trouve à Dudley en Angleterre, ont de très-grands rapports avec cette espèce; elles en diffèrent pourtant en ce que le bord ce celles d'Amérique se retrousse un peu en dessous, tandis que c'est le contraire pour celles d'Angleterre, dont le bord s'abaisse en dessous. On trouve à l'embouchure de la rivière des Alleghanys près de Pittsborough (Amérique septentrionale), dans un grès rougeâtre, des empreintes de coquilles qui ont beaucoup de rapports avec cette espèce, mais que sont plus aplaties."

We have here a good description of this American species accompanied by intelligible figures, and although the name has never been current among naturalists in this country, there seems sufficient reason to believe that it is the same species which was subsequently described as *Leptæna planumbona*,† a com-

* "Par plusieurs Professeurs du Jardin du Roi, et des principales Ecoles de Paris." The article "Strophomène" is signed with the initials "D. F."; Defrance, not de Blainville as usually quoted.

† Palæontology of New York, vol. i, p. 112. 1847.

mon fossil in the upper horizon of the Hudson River group in the Ohio valley. RAFINESQUE himself, did not define his genus STROPHOMENES in any American work until the publication of his tract of October, 1831,* where it appears in the following terms:

"*Strophomenes*, Raf. Equilateral, hinge broad, great valve notched by a lunulate sinus receiving a lunulate projection from the smaller valve."

In a tract published in Philadelphia in November, 1831, entitled, "Enumeration and Account of some remarkable Natural Objects in the Cabinet of Prof. Rafinesque in Philadelphia," p. 4,† the descriptions of the following species under STROPHOMENES are given:

"STROPHOMENES, Raf., 1820. See tract of October [1831]. 1. *Str. levigata.* Very smooth, longer valve convex, lower valve concave, corners acute, not auriculated; contour arched and even. Length, 4-5 of the breadth. Kentucky limestone. 2. *Str. flexilis.* Very thin, lower valve hardly concave, with minute curved strias; upper valve convex, with minute flexuose strias, corners acute subauriculate. Length and breadth equal. Limestone of Ohio, 1 or 2 inches."

In the absence of illustrations the descriptions of these species are too meager to allow of their identification. So far as known the name STROPHOMENES does not again occur in the writings of M. RAFINESQUE, and since these species have not subsequently been recognized or farther defined, the term STROPHOMENES, Rafinesque, in this connection can not be retained.

In 1846, KING‡ considered *S. rugosa* as congeneric with *Leptæna alternata*, Conrad. SHARPE,§ in 1848, takes *Orthis umbraculum*, Schlotheim, as the typical species of STROPHOMENA, including the *O. crenistria*, of PHILLIPS, thus making

* The title of this tract is as follows: "Continuation of a Monograph of the Bivalve Shells of the River Ohio, and other Rivers of the Western States. By Prof. C. S. RAFINESQUE. (*Published at Brussels, September, 1820.*) Containing 46 species, from No. 76 to No. 121. Including an Appendix on some Bivalve Shells of the Rivers of Hindostan, with a Supplement‖ on the Fossil Shells of the Western States, and the TULOSITES, *a new genus of fossils.* Philadelphia, October, 1831."

† Binney and Tryon's Reprint, p. 69.

‡ Annals of Natural History, vol. xviii, p. 36.

§ Quarterly Journal Geological Society, vol. iv, p. 78.

‖ In this tract he refers to the Monograph which he had sent to Brussels for publication in the "*Journal de Physique*," and writes: "I propose to give an epitome of this Monograph which I have not seen in print. I possess nearly all the shells." Then follows a list of the genera which he had there proposed under the order BRACHIOPIA; numbering altogether twenty-three generic terms.

the genus equivalent to ORTHOTHETES, of FISCHER DE WALDHEIM, 1837, as now defined.

In his "Monograph of the Permian Fossils of England" (1850, p. 103), Professor KING, under the head of "*Family* STROPHOMENIDÆ, KING, 1846," writes as follows:

"Rafinesque was the first to found a genus for shells belonging to this family. Whether his *Strophomena* were ever published by himself, or it first appeared under the editorship of some other author, I have not been able to ascertain: but this is certain, that the genus was described by M. de Blainville, in his 'Manuel de Malacologie,' 1825, and afterwards in the 'Dictionnaire des Sciences Naturelles,' t. li, 1827, in both of which it is typified by the American *Strophomena rugosa*, Raf., which, from its general form, and its large valve being concave, and the opposite one convex, I have little doubt is identical with the recently proposed *Strophomena* (*Leptæna*) *planumbona*, of Hall.*"

But KING also included in the genus "such shells as *S. alternata*, Conrad, *S. Dutertrii*, Murchison, *S. euglypha*, Dalman, *S. planoconvexa*, Hall, and several others": a group in which are now recognized three distinct generic types of adult characters In 1853,† Mr. DAVIDSON followed Professor KING in assuming as the type "*S. rugosa*, Raf.? = *S. planumbona* or *S. alternata*." This conception of the value of the genus Mr. DAVIDSON did not modify in any of his subsequent writings, except in his last reference to it, in the "General Summary" of 1884. The reversal of the relative convexity of the valves in the above species, which was indicated in DEFRANCE'S description of *S. rugosa*, and which is now regarded as an important morphological character, was not regarded by Mr. DAVIDSON as of high value. The fact that the reversed species have, in early growth-stages, the normal convexity which is retained throughout by such forms as *S. alternata*, was considered as evidence of homogenity; hence he included in this genus "all species agreeing with *S. planumbona*, *alternata*, *grandis*, *filosa*, *euglypha*, *funiculata*, *antiquata*, *pecten*, *expansa*, *depressa*, etc.," although in this list are species with normal convexity

* "Vide Palæontology of New York, vol. i, p. 112, pl. xxxi B, fig. 4; and Bull. de la Soc. Géol. de France, 2me série, t. v, pl. iv, figs. 3 *a*, *b*, *c*, *d*."

† Introduction British Fossil Brachiopoda, p. 105.

(*Rafinesquina alternata*, *R. expansa*, *Stropheodonta filosa*), reversed convexity (*Strophomena antiquata*, *Strophonella euglypha*, *S. funiculata*, *Orthothetes pecten*), and the typical LEPTÆNA (*L. depressa* = *rhomboidalis*, Wilckens). This application of the term STROPHOMENA is now in general usage, but it is quite too broad for the present requirements of classification. It is highly probable (almost certain indeed) that the specimens described by DE BLAINVILLE and DEFRANCE under this name had been sent by RAFINESQUE from America. DE CASTELNAU, in 1843,* in describing his species *Productus? sulcatus*, which is unquestionably an imperfect specimen of *L. rhomboidalis*, from the Corniferous limestone, says that the fossil had been communicated to him "as a STROPHOMENA of RAFINESQUE." It was also stated, in Volume III of the Palæontology of New York (page 175), that specimens of *L. rhomboidalis* in RAFINESQUE's collection, which came into the hands of Mr. CHARLES A. POULSON of Philadelphia, were labeled with the name *Strophomena rugosa*.

In 1873 Mr. MEEK† provisionally retained STROPHOMENA for *Leptæna rhomboidalis*, and referred the numerous resupinate forms he there described to HEMIPRONITES, though admitting the almost certain identity of *S. rugosa*, de Blainville, with *Leptæna planumbona*. Finally Mr. DAVIDSON, in 1884, in his last expression in regard to this genus, says: ‡"*Strophomena*, Rafinesque, 1820, has caused much confusion. It should, I think, be restricted to forms that agree with *Strophomena rhomboidalis*."

ŒHLERT, in 1887, takes *S. rhomboidalis* as the type of PANDER's PLECTAMBONITES, leaving under STROPHOMENA (with *S. rugosa*, Rafinesque (de Blainville), as the type), both the reversed and normally convex forms.§

It is evident from the foregoing review of the history of the name STROPHOMENA, that in justice to RAFINESQUE, both the genus and its type-species should be accredited to him; and although their interpretation and establishment are due to DE BLAINVILLE and DEFRANCE, we can not with propriety claim for these authors what they had no intention of claiming for themselves.

* Essai sur le Système Silurien de l'Amérique Septentrionale, p. 90.

† Palæontology of Ohio, vol. i, p. 73.

‡ General Summary, p. 379.

§ Fischer's Manuel de Conchyliologie, p. 1281.

Diagnosis. Shells transversely subsemicircular or semielliptical: greatest width along the hinge-line. Surface concavo-convex and covered with fine radiating striæ which are equal or alternate in size. The pedicle-valve is slightly convex about the umbo, but becomes rapidly concave toward the middle with the apex perforated, except in old age. The cardinal area is conspicuous and nearly vertical, and the delthyrium closed by a convex plate or deltidium. The teeth are widely divergent and are supported by plates which are produced into elevated ridges nearly surrounding the muscular area. The latter is relatively short, subcircular in outline, deeply excavated and divided medially by a more or less distinctly defined longitudinal ridge which is often continued over the pallial region.

The brachial valve is concave at the umbo, becoming strongly convex with growth; it has a much narrower cardinal area and the delthyrium is rudimentary or incomplete. Dental sockets deep, and continued as narrow grooves or indentations across the cardinal area. The crural plates are extended laterally with a slight curve, but are not supported by septa; at their inner margins they unite to form a callosity, upon which rests the short, bilobed cardinal process, which scarcely extends beyond the hinge-line. The muscular surface of this process is cordate in outline and is placed at a low angle to the plane of the area. A low median ridge extends forward from the hinge-plate separating two large adductor scars, in front of which are two narrow elongate impressions. Vascular and ovarian markings frequently well defined. Shell-substance fibrous, strongly punctate.

Type, *Strophomena rugosa* Rafinesque (de Blainville), 1825,=*Leptæna planumbona*, Hall, 1847, as recognized by King and other authors.

Limiting the term Strophomena by this strict construction, it will prove to be a genus of comparatively moderate vertical range, appearing so far as known not before the age of the Trenton (*Leptæna filitexta*, Hall, *Strophomena Thalia*, Billings, *S. fluctuosa*, Billings, *S. subtenta*, Conrad), and becoming quite abundant in the Hudson River group (*Leptæna planumbona*, Hall, *L. planoconvexa*, Hall, *Strophomena sinuata*, Emmons, *Hemipronites nutans*, Meek, *Strophomena Wisconsin-*

ensis, Whitfield, *Streptorhynchus cardinalis*, Whitfield, *Strophomena Hecuba*, Billings, *Streptorhynchus Hallie*,* S. A. Miller). With the close of the Lower Silurian in America, it seems to have abruptly disappeared, though in Europe the species *S. antiquata* is abundant in the Wenlock in England, Scotland and the Isle of Gotland. In the Niagara and Devonian faunas its place is taken by the genus ORTHOTHETES, with which its affinites are very close.

SUMMARY.

GENUS STROPHOMENES OR STROPHOMENA.

1820. RAFINESQUE proposed the name STROPHOMENES without giving either a diagnosis or the citation of any species under the genus.

1824. DEFRANCE, Tableau des Corps Organisés Fossiles, p. 6, used the generic term STROPHOMENES, citing RAFINESQUE as the author.

1825. DE BLAINVILLE, "Manuel de Malacologie et Conchyliologie," vol. i, p. 513, pl. liii, figs. 2, 2*a*, uses the name STROPHOMENA, citing the name of the genus as one proposed by RAFINESQUE, and also cites *Strophomena rugosa*, illustrating the species and giving RAFINESQUE as the author.

1827. DEFRANCE, "Dictionnaire des Sciences Naturelles," vol. li, p. 151, and "Atlas," reproduced the figures of DE BLAINVILLE, under the name *Strophomenes rugosa*, Rafinesque.

1831. RAFINESQUE defines the genus STROPHOMENES (October, 1831), referring to a former publication of 1820: and in November of the same year describes two species under the names *Str. levigata*, and *Str. flexilis*.

1850. Professor KING recognized the figures of *Strophomena rugosa* above referred to, as identical with *Strophomena* (*Leptæna*) *planumbona*, Hall, published in 1847.

This identification has been generally accepted, and the figures of DE BLAINVILLE, and of the Dictionnaire des Sciences, are recognized as a fair representation of the species.

* "The specific name is given as a compliment to Miss HALLIE COTTON, who was the first lady to join the Cincinnati Society of Natural History."—MILLER, Cincinnati Quarterly Journal of Science, p. 148. 1874.

GENUS ORTHOTHETES, FISCHER DE WALDHEIM. 1830.

PLATE IX, FIGS. 21-32; PLATE IXA, FIGS. 19-27; PLATE X, FIGS. 1-9; AND PLATE XIA, FIGS. 9-22.

1820. *Terebratulites*, SCHLOTHEIM. Die Petrefacktenkunde auf ihr. jetzig. Standpunkt, p. 256.
1830. *Orthothetes*, FISCHER DE WALDHEIM. Bull. Société Imp. Naturalistes de Moscou, vol. i, p. 375.
1836. *Spirifera*, PHILLIPS. Illustrations of Geology of Yorkshire, vol. ii, p. 216, pl. 9, fig. 6.
1837. *Orthis*, VON BUCH. Ueber Delthyris oder Spirifer und Orthis, p. 69, pl. ii, fig. 5.
1837. *Orthothetes*, FISCHER DE WALDHEIM. Oryctographie du Gouv. de Moscou, p. 133, pl. xx, figs. 4 a–c
1840. *Spirifer? Orthis*, SOWERBY. Trans. Geol. Soc. London, Second Ser., vol. v, pl. lvii, figs. 7, 12.
1840. *Orthis*, DE VERNEUIL. Bull. Société Géologique de France, vol. xi, p. 253.
1840. *Leptæna*, J. DE C. SOWERBY. Mineral Conchology, pl. dcxv, fig. 1 b.
1841. *Orthis*, DE VERNEUIL and D'ARCHIAC. Trans. Geol. Soc. London, Second Ser., vol. vi, p. 396.
1841. *Spirifer (?)*, PHILLIPS. Palæoz. Foss. Cornwall, Devon and W. Somerset, p. 66, pl. xxvii, fig. 113.
1842. *Strophomena*, CONRAD. Jour. Acad. Nat. Sci. Phila., vol. viii, pp. 257, 258, pl. xiv, fig. 12.
1842. *Strophomena*, VANUXEM. Geology of N. Y.; Rept. Third District, p. 122, fig. 6.
1843. *Strophomena*, HALL. Geology of N. Y.; Rept. Fourth District, p. 104, fig. 1; p. 266, figs. 2–4.
1843. *Orthis*, DE KONINCK. Animaux foss. du Terrain. Carbonif. de la Belgique, p. 222, pl. xiii, figs. 4–7.
1844. *Orthis*, MCCOY. Synopsis Carbonif. Foss. Ireland, pl. xx, fig. 18; pl. xxii, figs. 3–6.
1845. *Orthis*, DE VERNEUIL. Géol. de la Russie et des Montagnes de l'Oural, pp. 195, 196, pl. x, fig. 18, pl. xi, figs. 1–4.
1852. *Leptæna*, MCCOY. British Palæozoic Fossils, pp. 385, 388, pl. ii a, fig. 7.
1852. *Leptæna*, HALL. Palæontology N. Y., vol. ii, p. 60, pl. xxi, fig. 3; p. 259, pl. liii, figs. 8–10.
1853. *Orthis*, SCHNUR. Palæontographica, vol. iii, p. 216, pl. xxxviii, fig. 2; pl. xliv, fig. 4.
1854. *Orthisina*, SEMENOW. Zeitschr. der deutschen geologischen Gesellschaft, vol vi, pl. ii, fig. 1.
1855. *Orthisina (partim)*, DAVIDSON. Introd. British Fossil Brachiopoda, p. 104.
1855. *Orthisina*, The SANDBERGERS. Verstein. des rheinisch. Schichtensyst. in Nassau, p. 61.
1856. *Leptæna*, BILLINGS. Canadian Naturalist and Geologist, vol. i, p. 138, pl. ii, figs. 16, 17.
1857. *Orthis*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 44, 48, 50, figs. 1, pp. 97, 137.
1858. *Orthis*, HALL. Geology of Iowa, pt. ii, p. 490, pl. ii, fig. 6.
1859. *Strophomena*, HALL. Palæontology of N. Y., vol. iii, p. 174, pl. x A, fig. 13; pl. xv, fig. 3; pp. 192, 193, pl. xvii, figs. 1, 2; pl. xviii, fig. 3; pl. xxi, figs. 8, 9.
1860. *Streptorhynchus*, BILLINGS. Canadian Journal, vol. v, p. 226, figs. 12, 13.
1860. *Orthisina*, *Streptorhynchus*, HALL. Thirteenth Rept. N. Y. State Cab. Nat. Hist., pp. 80, 81, fig. 12; p. 112.
1861. *Streptorhynchus*, DAVIDSON. British Carboniferous Brachiopoda, p. 124, pl. xxvi, fig. 1; pl. xxvii, figs. 1–5; pl. xxx, figs. 14–16.
1862. *Streptorhynchus*, A. WINCHELL. Proc. Acad. Nat. Sci. Phila., vol. xiv, p. 140.
1862. *Streptorhynchus*, WHITE and WHITFIELD. Proc. Boston Soc. Nat. Hist., vol. viii, p. 293.
1862. *Streptorhynchus*, WHITE. Proc. Boston Soc. Nat. Hist., vol. ix, p. 28.
1863. *Streptorhynchus*, BILLINGS Geology of Canada, p. 369, fig. 384; p. 957, fig. 449.
(?) 1863. *Streptorhynchus*, DAVIDSON. Quarterly Journal Geological Society, London, p. 173, pl. ix, fig. 19.
1863. *Streptorhnychus*, HALL. Transactions Albany Institute, vol. iv, pp. 210, 226.
1863. *Streptorhynchus*, HALL. Sixteenth Rept. N. Y. State Cab. Nat. Hist., p. 63, figs. 1, 2.
1865. *Streptorhynchus*, DAVIDSON. British Devonian Brachiopoda, pp. 79–84, pls. xvi, xviii.
1865. *Streptorhynchus*, A. WINCHELL. Proc. Acad. Nat. Sci. Phila., vol. xvii, p. 117.
1866. *Crania (Pseudocrania)*, A. WINCHELL. Rept. Lower Penin. Michigan, p. 92.
1867. *Streptorhynchus*, HALL. Palæontology of N. Y., vol. iv, pp. 64–74, pl. iv, figs. 11–19; pl. ix, figs. 1–27; pl. x, figs. 1–24.
1868. *Hemipronites*, MEEK and WORTHEN. Geology of Illinois, vol. iii, p. 349, pl. vi, fig. 6.
1871. *Streptorhynchus*, KAYSER. Zeitschr. der deutschen geologischen Gesellschaft, vol. xxii, p. 615, pl. xiv, fig. 1.

1874. *Streptorhynchus*, HARTT. Bull. Buffalo Soc. Nat. Sci., vol. i, p. 248, pl. ix.
1874. *Streptorhynchus*, DERBY. Carbonif. Brachiopoda of Itaitúba, p. 37, pls. v, viii.
1874. *Streptorhynchus*, NICHOLSON. Palæontology Province of Ontario, p. 70.
1875. *Hemipronites*, MEEK. Palæontology of Ohio, vol. ii, p. 279, pl. x, fig. 5.
1877. *Hemipronites*, MEEK. Geol. Expl. Fortieth Parallel, vol iv, p. 35, pl. iii, fig. 2; p. 62, pl. vii, fig. 2.
1877. *Streptorhynchus*, HALL and WHITFIELD. Geol. Exploration Fortieth Parallel, vol. iv, p. 252, pl. iv, figs. 1-3.
(?) 1878. *Streptorhynchus*, DAWSON. Acadian Geology, Third Edition, p. 296, fig. 96.
1879. *Streptorhynchus*, HALL. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., pp. 150, 151, pl. xxi, figs. 26-33; pl. xxiii, figs. 11-13.
1882. *Streptorhynchus*, WHITFIELD. Annals N. Y. Academy of Sciences, vol. ii, pp. 193, 200.
1882. *Streptorhynchus*, HALL. Eleventh Rept. Indiana State Geologist, pp. 287, 288, pl. xxi, figs. 26-33; pl. xxiii, figs. 11-13.
1883. *Streptorhynchus*, HALL. Second Ann. Rept. N. Y. State Geologist, pl. xxxix, figs. 21-32; pl. xl, figs. 1-9; pl. xlii, figs. 16-27.
1884. *Streptorhynchus*, WALCOTT. Palæontology Eureka District, p. 117, pl. xiii, figs. 7, 16.
1884. *Orthothetes*, WAAGEN. Salt-Range Fossils, I, vol. iv (fas. 3), p. 607, pl. lv, figs. 1, 2.
1884. *Orthothetes*, DAVIDSON. General Summary British Fossil Brachiopoda, p. 379.
1887. *Streptorhynchus*, ŒHLERT. Etudes sur quelques Foss. Dévon de l'Ouest de la France.
1887. *Strophomena*, FOERSTE. Bull. Denison University, vol. ii, p. 105, pl. viii, figs. 31, 32, 34-38.
1888. *Hemipronites*. HERRICK. Bull. Denison University, vol. iii, p. 37, pl. iii, fig 24; pl. v, fig. 14; pl. vi, fig. 8; pl. ix, fig. 21; vol. iv, pl. ii, figs. 1, 5; pl. iii, fig. 12.
1889. *Streptorhynchus*, BEECHER and CLARKE. Memoirs N. Y. State Museum, vol. i No. 1.
1889. *Streptorhynchus*, NETTELROTH. Kentucky Fossil Shells, pp. 140-142, pl. xxix, figs. 11, 12; pl. xxxi, figs. 31-33.

DIAGNOSIS. Shells plano-convex or biconvex, sometimes becoming concavo-convex with age. Brachial valve usually the deeper in the pallial region; pedicle-valve highest about the umbo, which is sometimes much extended, and often shows a pronounced tendency to irregular growth. Surface covered with slender, subequal radii, which are crenulated by sharp concentric striæ. Hinge-line long, equaling, and often greater than the width of the shell; in some species frequently showing a tendency to auriculation at the extremities. Pedicle-valve with the cardinal area prominently developed; the delthyrium covered by a thick, more or less convex deltidium, which is rarely if ever perforated at maturity. On the interior the teeth are moderately large, sometimes thickened, but not supported by dental plates. The muscular area is marked by flabelliform cardinal scars, inclosing a small adductor impression; similar to that in RHIPIDOMELLA, but often very faint.

In the brachial valve the cardinal area is narrow, the deltidial covering small and emarginate at the center. The cardinal process is united to the crural plates, the whole forming a vertical subcrescentic process, most elevated

centrally and notched or divided at its crest, making it bilobed or bidentate, as seen from its inner surface: on its outer or posterior face each apophysis is deeply grooved, giving the entire cardinal process, from this point of view, a distinctly quadrilobate appearance. The crural plates end more or less abruptly in elevated points, which undoubtedly mark the place of attachment of the crura. The bases of the crural plates are not produced around the muscular area. Muscular impression flabelliform, very much as in the other valve; divided medially by a low faint ridge. Shell-substance strongly punctate.

Type, *Spirifer crenistria*, Phillips. American example, *Streptorhynchus Pandora*, Billings. Corniferous limestone.

Observations. This group of shells is distinguished from the Silurian Strophomenas by the following characters: the external form is subject to greater variation and especially so in the convexity of the valves; the area of the pedicle-valve is less constant, often higher, and not infrequently irregular or unequal on the two sides; the umbo is often distorted, and the apex seldom if ever perforated by a small round foramen as is always the case in young, and generally in mature individuals of Strophomena. The surface ornamentation is also coarser and more pronounced, and never so delicate as in *Strophomena planumbona*, and its congeners. The cardinal process does not merely rest upon a hinge-plate or umbonal callosity, but is distinctly coalesced with the crural plates. In Strophomena these plates make a sweeping outward curve and do not show the point of attachment of the crura, while in Orthothetes their divergence is less, and they terminate abruptly in crural apophyses; the character of the muscular impressions is quite different.

The group appears to be well-defined on the basis of these features, and subject to little variation. As already observed, Orthothetes appears directly upon the disappearance of the Strophomenas from the faunas of the Silurian (Clinton); perhaps its earliest representatives, so far as known, are *Strophomena subplana*, Conrad, and *Streptorhynchus tenuis*, Hall, of the Niagara group, followed in the Lower Helderberg by *Orthis deformis*, Hall, *Strophomena Woolworthana*, Hall; becoming an abundant form in the Devonian, represented by *Streptorhynchus Pandora*, Billings, *Orthis prava*, Hall, *Strophomena Chemungensis*, Conrad, and its

allies, *Orthis umbraculum*,* Schlotheim, and in the Carboniferous by *Streptorhynchus lens*, White, *Spirifer crenistria*,* Phillips, and others. A noticeable variation from the type of structure described, occurs in the Niagara species, *Orthothetes subplanus*, where the deltidium of the brachial valve constantly increases in size, from youth onward, while the deltidium of the opposite valve is very slightly developed.

The term ORTHOTHETES has not come into general use, on account of the want of clearness in its original definition. The species which are now included under it have been generally left with the designation STREPTORHYNCHUS, but accepting the views maintained by Dr. WAAGEN, the latter genus must be regarded as limited to the Carboniferous and Permian species. WAAGEN, in 1884, was the first to place FISCHER DE WALDHEIM'S name, ORTHOTHETES, upon a substantial basis He says:

"Though this name has been quoted as applied by EVANS to certain forms already in the year 1829, yet the genus can not be considered as fairly established before the year 1830, when in the first edition of the 'Oryctographie,' the interior of a dorsal valve, was distinctly figured and the genus definitely transferred to the Brachiopoda by FISCHER DE WALDHEIM. In the edition of 1830, only the interior of a dorsal valve was figured, whilst in the edition of 1837 an external view of a ventral valve is added.

"In both cases there can not remain the slightest doubt that the name was applied to a shell very nearly related to *Streptorhynchus crenistria*, Phill., and which, chiefly in the internal characters of the dorsal valve, is generically identical with PHILLIPS' species."†

DE WALDHEIM did not apply a specific name to his figured species, and subsequently, in 1850,‡ he described two species, *Orthothetes radiata* and *O. socialis*, the former of which has a strong median septum in the pedicle-valve, and both are probably referable to the genus DERBYA. DE VERNEUIL identified the figure given by DE WALDHEIM in 1837§ as the *Orthis arachnoidea*,‖ of

* These species have been recognized by most American authors as occurring in the Carboniferous rocks of America. It is doubtful whether a careful comparison of European specimens with the American forms will prove them identical.

† Salt-Range Fossils, 1, vol. iv (fas. 3), p. 607.

‡ ORTHOTHETES; genre de la Famille des Brachiopodes; Bull. Société Imp. Naturalistes de Moscou, p. 491, pl. x, figs. 1-4. 1850.

§ Oryctographie du Gouvernement de Moscou, p. 183, pl. xx, figs. 4, a, b, c.

‖ Géologie de la Russie d'Europe et des Montagnes de l'Oural, p. 196, pl. x, fig. 18; pl. xi, fig. 1.

PHILLIPS,* which form Mr. DAVIDSON has regarded† as but a variety of PHILLIPS' *Spirifer crenistria.*

This well known and widely distributed species (according to current authority), *Spirifer crenistria*, Phillips (= *Streptorhynchus crenistria*), may hence be taken as the type of ORTHOTHETES: and since this fossil, as recognized, is subject to considerable variation in the regularity and elevation of the umbo of the pedicle-valve, which is usually normal and symmetrical, but sometimes much distorted, it opens the genus to the reception of species in which this irregularity is usually present, and to those in which this condition does not appear.

GENUS HIPPARIONYX, VANUXEM. 1842.

PLATE IX, FIGS. 33-36; AND PLATE XVA, FIGS. 9-11.

1838. *Leptæna unguiformis*, CONRAD. First Ann. Rept. Palæont. Dept. N. Y. State Geol. Survey, p. 112 (not described).
1840. *Strophomena unguiformis*, CONRAD. Third Ann. Rept. Palæont. Dept. N. Y. State Geol. Survey, p. 203 (not described).
1841. *Atrypa unguiformis*, CONRAD. Fifth Ann. Rept. Palæont. Dept. N. Y. State Geol. Survey, p. 36 (not described).
1842. *Hipparionyx proximus*, VANUXEM. Geology of N. Y.; Rept. Third Dist., p. 124, fig. 29, No. 4 (not *H. consimilis* nor *H. similaris*, VANUXEM, p. 124).
1843. *Atrypa unguiformis*, (CONRAD) HALL. Geology of N.Y.; Rept. Fourth Dist., p. 149, fig. 60, No. 4.
1859. *Orthis hipparionyx*, HALL. Palæontology of N. Y., vol. iii, p. 407, pl. lxxxix, figs. 1-4; pl. xc, figs. 1-7; pl. xci, figs. 4, 5; pl. xciv, fig. 4.
1860. *Orthis unguiformis*, EMMONS. Manual of Geology, p. 129, fig. 115.
1881. *Orthis unguiformis*, DAVIDSON. ? Brachiopoda Budleigh-Salterton Pebble-bed, p. 347, pl. xxix, fig. 1.
1883. *Streptorhynchus hipparionyx*, HALL. Second Ann. Rept. N.Y. State Geologist, pl. 39, figs. 33-36.
Not *Orthis hipparionyx*, SCHNUR. 1853. Palæontographica, vol. iii, p. 217, pl. xl, fig. 1.
Not *Orthis hipparionyx?*, DAVIDSON. 1865. British Devonian Brachiopoda, p. 90, pl. xvii, figs. 8-11.

The remarkable shell described by Dr. VANUXEM as *Hipparionyx proximus*, so far as known, is the only representative of a peculiar association of streptorhynchoid characters. The name HIPPARIONYX has not been in general use, though, in the broad application of the generic term, which has been customary in this group of shells, it should have had precedence over STREPTORHYNCHUS. SCHNUR, in 1853, regarding what he believed to be a similar shell from the Eifel as an ORTHIS, took the liberty of changing VANUXEM'S name for the species

* Geology of Yorkshire, vol. ii, p. 220, pl. xi, fig. 4. 1836.

† British Carboniferous Brachiopoda, p. 127; British Devonian Brachiopoda, p. 81.

to *Orthis hipparionyx*, and by this designation the species has become generally known. It will, however, be necessary to return to both VANUXEM'S generic and specific terms.

DIAGNOSIS. Shell large, subhemispherical. In youth the pedicle-valve is very slightly convex, but at maturity it is depressed, or concave, over the pallial region. The brachial valve is always very convex. Marginal outline of the valve subcircular. On the pedicle-valve the hinge-line is straight but short, the cardinal area low, and the beak retrorse. The delthyrium is broad, and covered by an imperforate convex deltidium. The teeth are moderately large and are supported by lamellæ which extend to the bottom of the umbonal cavity, and are produced into strong ridges entirely surrounding the muscular area. This area is very large, having the structure of that in extreme examples of RHIPIDOMELLA, such as *Orthis musculosa*, and is composed of broad, flabellate diductors enclosing an elongate or cordate adductor impression There is a low median septum in the umbonal cavity, separating the arms of the cardinal process of the opposite valve, but it is quite short, disappearing at the adductor scar, though sometimes reappearing in front of it.

In the brachial valve there is no cardinal area. The cardinal process has essentially the same structure as in ORTHOTHETES and DERBYA, but is very high, its two branches completely traversing the umbonal cavity of the opposite valve: it is supported by a short, median septum, and laterally by strong crural plates which extend for a short distance along the margins of the muscular impressions; these are usually quite faint and undefined, occupying a much smaller area than in the pedicle-valve, and leaving arborescent markings as in some species of STROPHEODONTA. On the interior of both valves the margin is sharply pectinated, or crenulated, the crenulations on the brachial valve extending to the base of the cardinal process, and in the pedicle-valve extending for a considerable distance on the cardinal area. Surface of both valves covered with fine sharp radiating striæ.

Type, *Hipparionyx proximus*, Vanuxem.* Oriskany sandstone.

* VANUXEM also cited two other species of HIPPARIONYX, *H. consimilis* and *H. similaris*. and on page 132 of his report gives a figure probably intended for one of these species, under the name of *H. consimilaris*. This latter is a large, expanded form of *Atrypa reticularis*, from the Onondaga limestone.

Observations. The distinguishing characters of this genus are, (*a*) its orthoid external features, and muscular scars in the pedicle-valve; (*b*) the presence of strong dental lamellæ which are not known among the streptorhynchoids, except in Meekella; (*c*) the absence of any cardinal area on the brachial valve; (*d*) the presence of a slight median septum in both valves. *Hipparionyx proximus* is an abundant fossil in the Oriskany sandstone of New York, occurring also at Cumberland, Maryland, and in the arenaceous layers at the base of the Upper Helderberg in the Province of Ontario. The form from the Eifel referred to this species by Schnur is regarded by Kayser* as *Orthothetes umbraculum*, and the shells thus identified by Davidson, from the beds of Looe, Cornwall, and the Budleigh-Salterton pebbles, can not belong to the Oriskany species.

Genus KAYSERELLA, gen. nov.

1853. *Orthis*, Schnur. Palæontographica, vol. iii, p. 212, pl. xxxvii, fig. 3; pl. xxxviii, fig. 4; p. 218, pl. xlv, fig. 9.

1871. *Streptorhynchus?*, Kayser. Zeitschrift der deutschen geologischen Gesellschaft, vol. xxiii, p. 617, pl. xiv, figs. 2 *a, b, c, d, e*.

1885. *Streptorhynchus?*, Maurer. Kalke von Waldgirmes, p. 138, pl. v, fig. 10.

1886. *Streptorhynchus?*, Wenjukoff. Fauna des Devon. Syst. im nordw. und central Russl., p. 55, pl. ii, fig. 4.

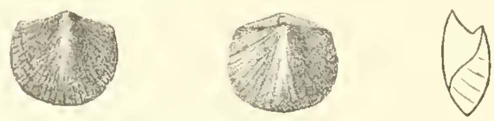
The species described as *Orthis lepida* by Schnur, in his work on the Brachiopoda of the Eifel,† has been shown by Professor Kayser to be a streptorhynchoid shell, with a covered delthyrium on the pedicle-valve and a very prominent median septum in the brachial valve, dividing the internal cavity much as in the Devonian forms of Scenidium, where the central plate is greatly developed. This is a feature not met with elsewhere among the fossils of this group, and though the internal characters of the species remain undefined, except the septum, this character alone must exclude it from any of the generic groups now recognized. That Professor Kayser recognized its generic value, is evident from his language:

"*Strept. lepidus* steht durch Gestalt, Form der Rippen und deutliche Perforation der Schale den Arten des Formenreihe der *Orthis circularis* zwar nahe,

* Zeitschr. der deutschen geologischen Gesellschaft, vol. xxiii, p. 615. 1871.

† Zusammenstellung und Beschreibung sämmtlicher im Uebergangsgebirge der Eifel vorkommenden Brachiopoden, nebst Abbildungen derselben; Palæontographica, *ut. cit.*

entfernt sich aber durch das grosse Dorsal septum und die Ueberdeckung der Stielöffnung doch so sehr von denselben, das ich es nicht gewagt habe, die Form jener Reihe einzufügen. Beide genannten Charaktere entfernen unsere Art von den echten Orthis-Arten überhaupt, und der letztere, das Pseudodeltidium auf der Ventral area, spricht für ihre Stellung bei *Streptorhynchus*. Doch hat der echte *Streptorhynchus* ein Pseudodeltidium auch auf der Dorsal area, welches ich bei *lepidus* vergeblich gesucht habe."



FIGS. 15, 16, 17. *Streptorhynchus? lepidus.* After KAYSER.

Though represented by only a single known species the form is an important one in the series of streptorhynchoid genera and it is therefore separated under the name above proposed.*

DIAGNOSIS.† Shell subsemicircular; hinge-line nearly equaling in length the greatest width of the shell; convexity normal. Pedicle-valve more convex than the brachial; area moderately high; delthyrium covered by a convex plate. Brachial valve slightly convex; area narrow; delthyrium covered. In the interior, a large, triangular median septum extends almost to the bottom of the opposite valve. Surface with a slight median ridge and furrow on brachial and pedicle-valves respectively; covered with sharp plications, increasing by intercalation near the margin.

Shell-substance punctate.

Type, *Orthis lepida*, Schnur. A somewhat rare species in the "Crinoidenschichten" of the Middle Devonian at Pelm and Gerolstein.

* The publication of this generic description in the present volume has received the approval of Professor KAYSER, and the name proposed is in recognition of the eminent services of that author in Geological and Palæontological Science.

† Derived from KAYSER's description of the type-species.

Genus DERBYA, Waagen. 1884.

PLATE X, FIGS. 10-17; PLATE XI, FIGS. 1-5, 18-22; PLATE XIA, FIGS. 23-39; PLATE XIB, FIGS. 1-8, 16, 17, 25, 21, AND PLATE XX.

1836. *Spirifer*, Phillips. Illustr. Geology of Yorkshire, vol. ii, pl. ix, fig. 5.
1844. *Orthis*, McCoy. Synopsis Carbonif. Fossils of Shetland, p. 123, pl. xxii, fig. 1.
1852. *Orthis*, Owen. Geological Rept. of Wisconsin, Iowa and Minnesota, pl. v, fig. 11.
1853. *Orthisina (partim)*, Davidson. Introd. British Fossil Brachiopoda, p. 104.
1855. *Leptœna*, McCoy. British Palæozoic Fossils, p. 452.
1858. *Orthis*, Hall. Geology of Iowa, pt. ii, p. 640, pl. xix, fig. 5; p. 173, pl. xxviii, fig. 5.
1858. *Orthisina*, Meek and Hayden. Proc. Acad. Nat. Sciences Phila., vol. x, p. 161.
1860. *Orthis*, McChesney. New Palæozoic Fossils, p. 32.
1861. *Streptorhynchus (partim)*, Davidson. British Carb. Brachiopoda, p. 124, pl. xxviii, figs. 2-7, 9.
1864. *Hemipronites*, Meek and Hayden. Rept. Palæont. Upper Missouri, p. 26, pl. i, fig. 7.
1868. *Hemipronites*, McChesney. Trans. Chicago Academy Sciences, p. 28, pl. i, figs. 5, 6.
1872. *Hemipronites*, Meek. Rept. Palæontology Eastern Nebraska, p. 174, pl. v, fig. 10; pl. vii, fig. 1.
1873. *Hemipronites*, Meek and Worthen. Geol. Surv. Illinois: Palæont., vol. v, p. 570, pl. xxv, fig. 12.
1874. *Streptorhynchus*, Derby. Carboniferous Brachiopoda of Itaitúba, p. 32, pls. vii, viii.
1878. *Streptorhynchus*, Abich. Bergkalkfauna aus der Araxesenge bei Djoulfa in Armenien, p. 73.
1883. *Streptorhynchus*, Hall. Second Ann. Rept. N. Y. State Geologist, pl. xl, figs. 10-17; pl. xli, figs. 1-3, 18-22.
1884. *Derbyia*, Waagen. Palæontologica Indica, Ser. xiii, vol. i, pt. iv, pp. 576, 591-607, pl. li, fig. 1; pl. lii, figs. 1-3; pl. liii, figs. 1-5; pl. liv, figs. 1-4; pl. lv, fig. 3.
1887. *Derbya*, Œhlert. Fischer's Manuel de Conchyliologie, p. 1285.
1887. *Hemipronites*, Herrick. Bull. Denison University, vol. ii, p. 50, pl. 2, fig. 19.

Diagnosis. General character of the shell as in Orthothetes. The external form is more variable, being usually plano-convex, rarely concavo-convex, the pedicle-valve often more elevated and subpyramidal, becoming irregular in its growth toward the apex. The interior of the pedicle-valve bears a high median septum, extending longitudinally through the center of the muscular area, which is from one-third to two-thirds the length of the valve: near the apex of the umbonal cavity it unites with the dental plates forming a small triangular chamber beneath the deltidium. In old shells this cavity is often filled by a testaceous secretion. The dental plates do not extend to the bottom of the rostral cavity except near the apex.

Brachial valve broad and regularly convex, or sometimes with an undefined median depression, and showing a tendency to auriculation. Cardinal area linear: the crural plates are abruptly elevated, and unite to form a strong erect cardinal process, which is distinctly bilobed at the summit; each lobe being slightly notched at the summit and distinctly grooved along the posterior face, the grooves uniting in a wider one at the posterior base of the process. Midway in their length these crural plates are marked by a transverse ridge

which terminates on their anterior face in points for the attachment of the crura; on the inside of the dental sockets there is a distinct, sometimes strongly defined ridge, extending along the lateral margin of the broad flabelliform muscular area, and gradually becoming obsolete. There is also a slight median ridge which becomes obsolete below the middle of the muscular area. Surface marked by strong, sharply elevated radii, which alternate with finer ones, all being crenulated, and the intermediate space cancellated by fine concentric striæ.

Type, *Derbya regularis*, Waagen. Upper Carboniferous. American example, *Orthisina crassa*, Meek and Hayden. Upper Coal Measures.

OBSERVATIONS. The validity of this genus rests entirely upon the presence of the median septum in the pedicle-valve. In some other groups of the brachiopods one might question the advisability of giving so much importance to a feature of this kind, which is often very variable even in a given species, but the study of the streptorhynchoid shells has led to the endorsement of Dr. WAAGEN's views in regard to the value of septal characters in this group. In none of the other genera, STROPHOMENA, ORTHOTHETES, MEEKELLA, STREPTORHYNCHUS, does such a septum exist, and so far as known, it exists only in this very restricted group of fossils which first appears in the Carboniferous and disappears in the Permian. In the character of the cardinal process and crural plates there is no essential difference between DERBYA and ORTHOTHETES. Species of the former genus are often of very great size (*D. grandis*, *D. regularis*, Waagen, *D. robusta*, *D. Keokuk*, Hall), and in consequence the cardinal process becomes of very striking proportions, but structurally not different from ORTHOTHETES, as shown by all the smaller species of DERBYA. Of American species to be placed in this genus are the *Orthis Keokuk*, Hall, from the Keokuk limestone of the Lower Carboniferous, *Orthis robusta*, Hall, from the Lower Coal Measures of Illinois, *Hemipronites crassus*,* Meek and Hayden, also from the Coal Measures, and *Streptorhynchus Correanus*, Derby, from the Carboniferous limestone of Itaitúba, Province of Pará, Brazil. In the Carboniferous of Great Britain occur the species *Spirifer senilis*, Phillips, and *Orthis cylindrica*, McCoy. Dr. WAAGEN has

* MEEK regarded MCCHESNEY's species, *Hemipronites Lasallensis* and *H. Richmondi*, described in 1860, from the Coal Measures of Illinois, as synonymous with *H. crassus*. See Palæont. Eastern Nebraska, p. 174.

added six species from the Carboniferous or Permo-Carboniferous of the Salt-Range, and ABICH, in 1888, described two forms from Armenia as varieties of *Streptorhynchus crenistria*, Phillips, viz., *S. eusarcus* and *S. incurvus*, both of which Dr. WAAGEN regards as belonging to DERBYA. On the basis of these forms he has made a conventional subdivision of the group into *Camerati* and *Septati;* in the former, the dental lamellæ do not extend along any part of the rostral cavity; in the latter are species like *D. Correana* and *D. robusta*, where the median septum unites at the apex of the umbonal cavity with the dental lamellæ forming a minute triangular vault. This peculiarity is most conspicuously developed in *Derbya Correana*, and is a natural result from the great height of the cardinal area.* In *Derbya crassa* and others of the *Septati* where the rostral cavity has become largely filled up by testaceous matter, a slight abrasion of the beak shows this union of the septum with the dental lamellæ.

On the internal surface of a brachial valve of *Productus Nebrascensis*, from the upper Coal Measures, near Kansas City, Missouri, there occurs a little group of twelve minute pedicle-valves, all closely affixed to their host by their entire external surface. With but two exceptions, the members of this cluster are oriented alike, having their hinge-lines parallel to the hinge-line of the PRODUCTUS, but their anterior margins directed toward the posterior margin of the latter. Three of the individuals show a broad cardinal area, and deltidium, and bear a conspicuous median septum in the muscular area, thus having the characters of DERBYA. Their gregarious occurrence and small size are evidences of immaturity. The frequent distortion of mature pedicle-valves of DERBYA, and the occasional retention of a cicatrix at the apex, are evidences of an adherent condition in early stages of growth, which are confirmed by this interesting specimen, of which an illustration is given upon Plate XI B.

Two interesting new forms of this genus are described and illustrated in this volume, viz., *Derbya Broadheadi* and *D. Bennetti*, from the Upper Carboniferous limestone of Missouri and Kansas, the former a large species with but a moderately high area, the latter a smaller form having much the expression of a MEEKELLA, with very high area, and an extremely high internal septum.

* See figure on Supplementary plate.

GENUS MEEKELLA, WHITE and ST. JOHN. 1868.

PLATE X, FIGS. 18-23; AND PLATE XIB, FIGS. 18-22.

1837. *Choristites (partim)*. FISCHER DE WALDHEIM (*fide* VERNEUIL). Oryctogr. du Gouvern. de Moscou. p. 141, pl. xxii, fig. 4.
1845. *Orthis*, DE VERNEUIL. Géol. de la Russie d'Europe et des Montagnes de l'Oural, pp. 192–194, pl. ix, figs. 2, 3 (*Productus*, EICHWALD. Coll. du Corps des Mines de St. Pétersb.).
1857. *Plicatula*, COX. Owen's Rept. Geological Survey Kentucky, vol iii, p. 568, pl. viii, fig. 7.
1858. *Orthisina*, SWALLOW. Trans. St. Louis Academy of Science, vol. i, pp. 183, 219.
1859. *Orthisina*, MEEK and HAYDEN. Proc. Acad. Nat. Sci. Phila., p. 26.
1861. *Streptorhynchus*, NEWBERRY. Lieut. Ives' Rept. Colorado River; Palæontology, pt. iii, chap. xi, p. 126, pl. i, fig. 5; pl. ii, figs. 11–13.
1866. *Orthis*, GEINITZ Carbon. and Dyas in Nebraska, p. 48, pl. iii, figs. 22–24.
1868. *Meekella*, WHITE and ST. JOHN. Trans. Chicago Academy Sciences, vol. i, p. 120, figs. 4–6.
1872. *Meekella*, MEEK. Palæontology of Eastern Nebraska, p 175, pl v, fig. 12.
1873. *Meekella*, MEEK and WORTHEN. Geological Survey of Illinois, vol. v, p. 571, pl. xxvi. fig. 21.
1874. *Meekella*, BAYAN. Bull. Société Géol. France, Ser. 3, vol. ii, p. 412, pl. xvi, fig. 3.
1875. *Meekella*, WHITE. Wheeler's Rept. Expls. and Surveys West 100th Merid., vol. iv, pt. i, p. 126, pl. ix, fig. 4.
1883. *Streptorhynchus (Meekella)*, HALL. Rept. N. Y. State Geologist for 1882, pl. xl, figs. 18-23.
1884. *Meekella*, WHITE. Thirteenth Report State Geologist Indiana, p. 130, pl. xxvi, figs. 12–14.
1884. *Meekella*, DAVIDSON. General Summary of British Fossil Brachiopoda, p. 379.
1884. *Meekella*, WAAGEN. Salt-Range Fossils, vol. i, pl. iv, p. 576.

DIAGNOSIS. Shell robust, biconvex, often subpyramidal. Hinge-line straight and shorter than the greatest width of the shell. On the pedicle-valve the cardinal area is often greatly elevated and distorted; the delthyrium is covered; the convex portion of the deltidium being much narrower than the space between the dental ridges. In the interior the teeth are prominent and supported by septiform dental lamellæ which reach the bottom of the umbonal cavity and extend forward for one-third or one-half the length of the shell. The brachial valve has a full, gibbous umbo, and a rudimentary or linear cardinal area. On the interior are two divergent lamellæ or crural plates, which are extended forward for more than one-third the length of the valve, supporting a high, erect cardinal process, which sometimes reaches almost to the apex of the umbonal cavity in the opposite valve. This process is a somewhat curved, thin, crescentic plate, bearing on its summit two slender median apophyses, below which are two stouter lateral projections having the form of extended, rounded lobes, which form the bases of the crura. Surface of the valves

marked with coarse costæ, which, with the interspaces, are covered by fine radiating plumose striæ. Shell-substance fibrous, punctate.

Type, *Plicatula striatocostata*, Cox. Upper Carboniferous.

OBSERVATIONS. MEEKELLA embodies the extreme development attained by certain features in the streptorhynchoid brachiopods. It has been noticed that in DERBYA the dental lamellæ are septiform only in the apex of the umbonal cavity; that in HIPPARIONYX this character is more positive. In MEEKELLA the great development of these lamellæ is subject to some variation, depending primarily upon the depth of the umbonal chamber. Dr. WAAGEN remarks* that in an American specimen labelled *Meekella striatocostata*, he was unable to discover any trace of dental lamellæ, and infers, from this fact, that there is probably present, in our Upper Carboniferous fauna, a species of the type of *Streptorhynchus pectiniformis*, Davidson, a form remarkable for having the peculiar exterior characters of MEEKELLA, and which was thus referred by Mr. MEEK,† who also observed the absence of septa in the Indian species, *S. pectiniformis*, and inferred a generic difference between it and MEEKELLA in case this absence were not accidental.

The remarkable cardinal process in this genus is a feature of important significance. In the pectenoid species of STREPTORHYNCHUS, such as that already mentioned‡ and *S. Hallianus*, Derby (see Plate XI, figs. 6–17), it does not appear that there is a very close approach to MEEKELLA in this respect, though herein the Brazilian species is not in strict agreement with *Streptorhynchus pelargonatus*.

Meekella striatocostata is not an uncommon fossil in the Middle and Upper Coal Measures of the interior and western States on the east side of the Rocky Mountains; but is not known in localities east of Illinois and Kentucky, "nor anywhere in the Lower Coal Measures."§ This species was described under

* Salt-Range Fossils, Brachiopoda, p. 589.

† Palæontology of Eastern Nebraska, p. 170, pl. v, fig. 16.

‡ WAAGEN has described this process in *S. pectiniformis* as having precisely the same structure as that in *S. pelargonatus* according to the figures given by DAVIDSON.

§ See Final Report U. S. Geological Survey of Nebraska, p. 177. 1872.

the name *Orthisina Missouriensis* by SWALLOW, and it is probably identical with *O. occidentalis* of the same author. Dr. NEWBERRY has described* the species *Streptorhynchus pyramidalis*, and *S. occidentalis*; the former of these may be identical with *Meekella striatocostata*, though the original specimen appears to be of very large size and of rather more pronounced plication. Figures of the original specimens of the latter species are given on Plate XI C, showing it to be very distinct from *M. striatocostata*, and the largest known representative of the genus. In 1845 DE VERNEUIL described from the middle and lower Carboniferous limestone of Russia, *Orthis eximia*,† and *O. Olivierana*, both of which unquestionably belong to MEEKELLA, the former being of the type of *M. striatocostata*, the latter an evenly striated shell without the radiating costæ, a type of surface ornamentation otherwise unrepresented in this group. Still another species has been described by BAYAN,‡ *M. Garnieri*, from some fossils collected in the valley of the Yangtsee-Kiang, China, by the late M. FRANCIS GARNIER.

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* Ives' Report Colorado River of the West, p. 126.

† According to DE VERNEUIL this is the *Productus eximius* of VON EICHWALD, and the *Choristites Watcotti* of FISCHER DE WALDHEIM.

‡ Sur quelques Fossiles Paléozoiques de Chine, *op. cit.*

Genus STREPTORHYNCHUS, King. 1850.

PLATE XI, FIGS. 6-17; PLATE XIB, FIGS. 9-15; AND PLATE XX.

1816. *Terebratulites*, Schlotheim. Denkschr. d. K. Akad. d. Wissenschaft, in München, vol. vi, p. 28, pl. viii, figs. 21–24.
1837. *Orthis*, von Buch. Ueber Delthyris oder Spirifer und Orthis, p. 62.
1848. *Orthis*, Geinitz. Verstein. d. Deutsch. Zechsteingebirges, p. 13, pl. v, figs. 11–15.
1850. *Streptorhynchus*, King. Monogr. Perm. Fossils England, p. 109, pl. x, figs. 18–28.
1853. *Orthisina*, Davidson. Introd. British Foss. Brachiopoda, p. 104, pl. viii, fig. 156.
1857. *Streptorhynchus*, Davidson. British Permian Brachiopoda, p. 32, pl. ii, figs. 32–42.
1861. *Orthis*, Geinitz. Dyas, vol. i, p. 92, pl. xvi, figs. 26–34.
1862. *Streptorhynchus*, Davidson. Quart. Journ. Geol. Society, vol. xviii, p. 3, pl. i, figs. 17, 18.
1863. *Streptorhynchus*, de Koninck. Fossiles Paléoz. de l'Inde, p. 37, pl. x, fig. 17.
1871. *Orthis*, Quenstedt. Petrefaktenkunde Deutschlands; Brachiopoden, p. 548, pl. lv, figs. 51–56.
1874. *Streptorhynchus*, Derby. Carbonif. Brach. Itaitúba, p. 35, pls. v, viii.
1880. *Streptorhynchus*, Davidson. British Permian Brachiopoda, Suppl., p. 243, pl. xxx, fig. 3.
1884. *Streptorhynchus*, Waagen. Salt-Range Fossils, vol. i, pp. 576–591, pl. l, figs. 3–9; pl. lv, figs. 4–13.
1887. *Streptorhynchus* (*Orthothetes*), Œhlert. Fischer's Manuel de Conchyl., Brach., p. 1284, fig. 1050

Diagnosis. Shells somewhat trihedral and subpyramidal, with base convex; hinge-line shorter than the greatest width of the valves. Pedicle-valve having the beak acute and often incurved and distorted. Cardinal area high, somewhat incurved; delthyrium covered by a broad, imperforate, depressed-convex deltidium. The interior of the valve with low dental ridges terminating in teeth of moderate size; these ridges are not septiform and do not continue to the bottom of the umbonal cavity; there is no median septum; muscular scars strong and flabelliform.

In the brachial valve the cardinal area is linear, the crural plates are vertical and abruptly elevated on their anterior edges, forming points of attachment for the crura; these unite to form a subcrescentic plate, from the center of which arises a broad, erect cardinal process, which is deeply divided into two lobes, each of which is faintly grooved at its summit and on the posterior face; muscular area small, divided medially by a low ridge. Exterior surface covered by fine radiating striæ.

Type, *Terebratulites pelargonatus*, Schlotheim. Permian.

Observations. According to Dr. Waagen's determination it will probably be necessary to restrict this genus to species agreeing with the above mentioned characters of *S. pelargonatus*. Though the relationship of this group with the

genera DERBYA and ORTHOTHETES is very close, there are appreciable differences: (1) in the general form of the shell; (2) the absence of true dental lamellæ; (3) the absence of a median septum in the pedicle-valve; (4) the character of the divaricating cardinal process. The structure of the last-mentioned feature differs from that in ORTHOTHETES and DERBYA, in being thinner, sharper, much higher and more deeply furcate The grooving of the posterior faces of the tips of the cardinal process, as illustrated by DAVIDSON,* gives to this organ a very similar character to that in *Triplecia Ortoni*.

As thus restricted, the genus has a comparatively meagre representation. Seven species have been described from the Permo-Carboniferous of the Salt-Range of India. Dr. DAVIDSON had previously described one species, *S. pectiniformis*, from the same country; and Dr. DERBY described *S. Hallianus*, from Itaitúba, Brazil. The only species known in European faunas is *S. pelargonatus*, and in North America the genus, so far as our present knowledge reaches, is represented by a single species, *S. Ulrichi*, sp. nov. from the Chester limestone. Dr. WAAGEN has divided the genus into two sections: I. *Simplices*, in which the surface is simply covered with radiating striæ; II. *Plicati*, in which the surface is plicated as well as striated, as in MEEKELLA. Of the former, *S. pelargonatus*, Schlotheim, is a typical representative, and *S. Hallianus*, Derby, of the latter. In regard to the range of STREPTORHYNCHUS, this author observes:

"The genus seems in Europe to be restricted to the Permian period, though perhaps some forms that occur in the Mountain limestone might also belong to it. In the Salt-Range the different species are distributed through the whole mass of the Productus limestone, from the lowest to the topmost beds. The first section, the *Simplices*, is restricted to the lower and middle divisions whilst the second section, the *Plicati*, chiefly occurs in the upper divisions."

* Permian Brachiopoda, pl. ii, fig. 39.

Genus TRIPLECIA,* Hall. 1858.

PLATE XI c, FIGS. 1-22.

1842. *Terebratula*, von Eichwald. Urwelt Russlands, vol. ii, p. 49, plate ii, figs. 6 a, b, c.
1842. *Atrypa*, Emmons. Geology of N. Y. ; Rept. Second District, p. 395, fig. 6.
1845. *Spirifer*, de Verneuil. Géol. Russ. et des Mont. de l'Oural, p. 149, pl. viii, fig. 7.
1846. *Orthis*, *Producta*, McCoy. Synopsis Silurian Foss. Ireland, p. 25, pl. iii, fig. 3; p. 30, pl. iii, fig. 12.
1847. *Atrypa*, Hall. Palæontology of N. Y., vol. i, pp. 137, 139, pl. xxxiii, figs. 1, 2 ; pl. xxxiii*, fig. 1.
1848. *Orthis*, Phillips and Salter. Mem. Geol. Surv. United Kingdom, vol. ii, p. 289.
1852. *Hemithyris*, McCoy. British Palaeozoic Fossils, p. 201.
1858. *Triplesia*, Hall. Twelfth Rept. N. Y. State Cab. Nat. Hist., p. 41, figs. 1-3.
1859. *Spirifer*, von Eichwald. Lethæa Rossica, vol. i, p. 697.
1859. *Triplesia*, Hall. Palæontology of N. Y., vol. iii, pp. 522, 523, figs. 1-3.
(?) 1861. *Camarella*, Billings. Canadian Naturalist and Geologist, vol. vi, p. 318, fig. 3.
(?) 1863. *Camarella*, Billings. Geology of Canada, p. 231, fig. 247.
(?) 1865. *Camarella*, Billings. Palæozoic Fossils, vol. i, p. 220.
1866. *Orthis*, Salter. Mem. Geol. Surv. United Kingdom, vol. iii, p. 697.
1869. *Triplesia*, Davidson. British Silurian Brachiopoda, pp. 197-201, pl. xxiv, figs. 29, 31, 32, pl. xxv, figs. 3-5.
1871. *Orthis*, Davidson. British Silurian Brachiopoda, p. 273, pl. xxxvii, figs. 3-15.
1872. *Dicraniscus*, Meek. American Journal of Science, Third Ser., vol. iv, p. 280.
1873. *Triplesia*, Meek. Geological Survey Ohio ; Palæontology, vol. i, pp. 176-179, pl. xv, figs. 1 a-k.
1877. *Triplesia*, Whitfield. Ann. Rept. Geol. Survey of Wisconsin, p. 51
1882. *Triplesia*, Whitfield. Geology of Wisconsin, vol. iv, p. 172, pl. x, figs. 1, 2.
1883. *Triplesia*, Davidson. British Silurian Brachiopoda. Suppl., pp. 141-147.
(?) 1884. *Triplesia*, Walcott. Palæontology Eureka District, p. 75, pl. xi, figs. 7, 8.
1889. *Triplesia*, Whitfield. Bull. American Museum Nat. Hist., vol. ii, No. 2, p. 43, pl. vii, figs. 5-8.
Compare *Streptis*, Davidson. Geological Magazine, vol. viii, p. 150, pl. v, fig. 13. 1881 ; and British Silurian Brachiopoda. Suppl., p. 139.

Diagnosis. Shell trilobate, transverse, unequally biconvex. Hinge-line straight and quite short. Pedicle-valve shallow, convex about the beak, but depressed anteriorly by a broad and deep median sinus; cardinal area low, erect and well defined ; delthyrium covered by a narrow, convex plate, with a circular foramen at the apex. In the interior the teeth are well developed and supported by short dental lamellæ longitudinally dividing the umbonal cavity near its apex. Muscular area small, comprising two lateral scars, separated by a longer central adductor impression. The brachial valve is very convex, and bears a strong median fold. The cardinal area is very narrow and the beak closely incurved. In the interior is an erect cardinal process, which is deeply

* The derivation of the term "Triplesia," as it is currently written, was given in the original description as from τριπλάσιος = *triplasius*. The correct form of the word, therefore, would have been Triplasia, but this term appears to have been already in use. Dr. Œhlert has suggested the change to Triplecia, which involves a derivation from a different root, τριπλεκής = *triplex*.

bifurcated, the distal extremity of each branch bearing a single deep groove. This process is supported on a subrostral callosity, which also bears two short spiniform crural points at its base. Shell-substance fibrous, impunctate (?). Surface with obscure concentric growth-lines, and fine radiating striæ on the inner laminæ; in rare instances there are radiating lines on the exterior.

Type, *Atrypa extans*, Emmons. Trenton limestone.

Observations. The species of this genus appear to be subject to considerable variation, and there still remains some doubt as to the proper limitation of the group. Triplecia, Streptis and Mimulus are terms which, with a little latitude, one might regard as of equivalent value. Adhering, however, pretty strictly to the type of structure exemplified in *Triplecia extans*, we shall have for Triplecia a much more compact and homogenous division, comprising such species as *Atrypa extans*, Emmons; *A. cuspidata*, Hall; *A. nucleus*, Hall; *Orthis insularis* von Eichwald; *Triplesia Wenlockensis*, Davidson, and perhaps *Camarella calcifera*, Billings,* and some others.

Triplecia Ortoni, Meek, the type-species of this author's genus, Dicraniscus,† is a large, ponderous shell, retaining the subtrihedral form, and essentially the internal characters of Triplecia, though the dental lamellæ are obscured by complication with the thick testaceous deposit usually found in the umbonal cavities of both valves. There is apparently no good reason for not regarding *T. Ortoni* as strictly congeneric with *T. extans*.

Mr. Davidson has referred to Triplecia, with some doubt, a number of species whose precise affinities have yet to be demonstrated. Of these are *Atrypa? apiculata*, Salter; *Triplesia? Maccoyana*, Davidson; *Atrypa? incerta*, Davidson; *Producta monilifera*, McCoy, and *Triplesia? Grayæ*, Davidson.‡ In *Atrypa* (*Tri-*

* The relations of this species are not well understood. The external form of the shell is that of *T. extans*, but in the specimens examined there appears to be a short median septum in the pedicle-valve, and no cardinal process in the brachial valve. It may prove necessary to separate this and the *T. primordialis* of Whitfield, from this genus. The *T. lateralis*, Whitfield, from the Fort Cassin beds (Calciferous sandstone), contains a spoon-shaped process in each valve, that in the pedicle-valve being supported by a median septum. It therefore becomes necessary to remove this form to a distinct genus, and to a different association and it will be described and illustrated in its proper place under the name Syntrophia.

† After becoming acquainted with the internal characters of *Triplecia extans*, which at that date had not been made public, Mr. Meek withdrew this generic term.

‡ See Silurian Supplement, pp. 144–147, pl. viii, figs. 24–32.

plecia?) *apiculata* and *A.* (*T.?*) *incerta*, the cardinal area is remarkably high and erect, and the median fold is on the pedicle-valve instead of on the brachial valve, as in the typical species. Should these prove genuine Triplecias, the reversal of the relative convexity of the valves will be an occurrence similar to that observed in the species of MIMULUS. The species *Producta* (*T.?*) *monilifera* appears to be a normally symmetrical, or slightly unsymmetrical (see plate XXV, fig. 5) STREPTIS, and the *T.? Grayæ*, a form with an erect cardinal area and a strongly radiate surface ornamentation. In one of these radiated species, the *Orthis spiriferoides*, McCoy, from the Upper Llandeilo and Caradoc, the existence of the peculiar articulating apophyses of TRIPLECIA has been demonstrated. (See Plate XI A, figs. 10, 11.) This species was referred to TRIPLECIA with doubt by Mr. DAVIDSON, but the certainty of its being congeneric with *T. extans* in these important features, opens the genus for the present to the reception of similar radiated shells. Another excellent representative of this type of structure is the *Orthisina cava*, Barrande,* from the Etage D_2.

Leaving out of consideration the *Camarella calcifera*, Billings, and the *Triplecia primordialis*, Whitfield, the earliest known representative of this genus in American faunas, appears to have been such a radiated form, *T. radiata*, Whitfield, from the Calciferous fauna at Beekmantown, N. Y. In the fauna of the Trenton group are *T. extans*, *T. cuspidata* and *T. nucleus;* the only other member of the genus known in this country being the *T. Ortoni*, from the Clinton fauna of Ohio.

* Système Silurien du Centre de la Bohême, vol. v, pl. 59, figs. iv, 1-7.

GENUS MIMULUS, BARRANDE. 1879.

PLATE XIc, FIGS. 23-32.

1878. *Spirifera* (?), MILLER and DYER. Journal Cincinnati Soc. Nat. Hist., vol. i, p. 37, pl. ii, fig. 3.
1879. *Triplesia*, HALL. Trans. Albany Institute, vol. x. Abstract, p. 16.
1879. *Mimulus*, BARRANDE. Système Silurien du Centre de la Bohême, vol. v, p. 109, pl. 1, fig. iii; pl. 9, figs. iii, iv, vi.
1882. *Triplesia*, HALL. Eleventh Ann. Rept. State Geologist of Indiana. p. 298, pl. xxvii, figs. 19-22.
1889. *Streptis*. BEECHER and CLARKE. Memoirs N.Y. State Museum, vol. i, No. i, p. 30, pl. iii, figs. 9, 10.

The affinities of this peculiar group of fossils have not hitherto been correctly understood. M. BARRANDE has given no clue to the interior characters of the shells, and as the genus has been recognized only in the Bohemian basin it has not been closely studied by other authors.* After a careful comparison of M. BARRANDE's figures of the Bohemian species with the fossil known as *Triplesia pu'illus*, Hall, or *Spirifera Waldronensis*, Miller and Dyer, from the Niagara fauna of Indiana, there remains little doubt of their being congeneric forms.

The DIAGNOSIS of the genus, given by M. BARRANDE, is in the following terms:

" Cette forme extérieure est complètement inverse de celle de Spirifer, en ce que le bourrelet, bien marqué, se trouve sur la valve ventrale, tandisque le sinus correspondant se montre sur la valve dorsale.

" La charnière est droite, mais n'occupe pas toute la largeur du fossile. L'aréa bien développée présente sous le crochet une ouverture triangulaire, fermée par un deltidium, jusqu'au crochet. Celui-ci parait conserver un petit trou rond, que nous observons sur un spécimen non figuré.

" Il est rare de pouvoir observer le deltidium, parceque la trace de la soudre avec l'aréa est complètement effacé.

" Les 2 espèces typiques, *Mim. perversus* et *Mim. moera*, Pl. 9, présentent exactement les caractères, que nous venons d'exposer."

The exterior form of these shells is subtrihedral like TRIPLECIA, and is subject to some variation, for of the three species described by M. BARRANDE, two, *M. perversus* and *M. moera*, have the strong median fold on the pedicle-

* ZITTEL (Handbuch der Palæontologie, vol. i, p. 684) made it a sub-genus of SPIRIFER, and ŒHLERT (FISCHER's Manuel de Conchyliologie; Brachiopodes, p. 1313) placed it with doubt under the family *RHYNCHONELLIDÆ*.

valve, while the other, *M. contrarius*, has it on the brachial valve. Again, all the Bohemian species appear to be bilaterally symmetrical shells, while the American *Mimulus Waldronensis*, which has the fold on the brachial valve, is always unsymmetrical in its mature condition, and may thus bear pretty much the same relation to *M. contrarius* as Streptis does to Triplecia.

A most striking feature in these shells is the character of the cardinal area, which usually in Bohemian species, and invariably in the American form, is smooth and without any superficial evidence of the delthyrium. In fact this opening is closed by a thin flat plate, which may be sometimes broken away or be absent from other causes, as appears from some of Barrande's figures.* It has been shown† that in a very early growth-stage in *M. Waldronensis* the delthyrium is open and its apical termination circular. While the delthyrium becomes closed, apparently by lateral accretion to the walls of the fissure, this foramen is retained until maturity.‡ In the interior of this valve in *M. Waldronensis* there are no dental lamellæ, in which respect the genus differs from Triplecia. The brachial valve bears an erect, deeply bifurcated cardinal process, of quite similar character to that in *Triplecia extans*. The other interior features of Mimulus are still unknown, but those described are sufficient to demonstrate the close alliance of these shells with the streptorhynchoids. All the Bohemian species are from the Etage E_2, which is the equivalent of the Niagara fauna.

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* See Barrande, pl. 9, figs. iv, e, g.

† Beecher and Clarke, *op. cit.*

‡ It will be observed that in Triplecia, Streptis and Meekella, the median convex ridge of the deltidium is very narrow, occupying but a small part of the area between the dental plates. The obliteration of this low ridge would show a character similar to that of the deltidium in Mimulus.

Genus STREPTIS, Davidson. 1881.

PLATE XIc, FIGS. 33-39.

1848. *Terebratula*, Davidson. Bull. Soc. Géol. de France, 2nd sér., tom. v, p. 331, pl. iii, fig. 33.
1859. *Rhynchonella*, Salter. In Murchison's Siluria, p. 250.
1860. *Spirigerina?*, Lindström. Gotland's Brachiopoder, p. 364.
1867. *Atrypa?*, Davidson. British Silurian Brachiopoda, p. 141, pl. xiii, figs. 14-22.
1879. *Atrypa?*, Barrande. Système Silurien du Centre de la Bohême, vol. v, pl. 83.
1881. *Streptis*, Davidson. Geological Magazine, vol. viii, p. 150, pl. v, fig. 13.
1883. *Streptis*, Davidson. British Silurian Brachiopoda, Suppl., p. 39.

From what is known of the single species of this genus, *S. Grayi*, from the Wenlock limestone, it would appear that its internal characters are essentially similar to those of Triplecia. Mr. Davidson says that he was unable to determine the precise character of the cardinal process, but an imperfect interior, illustrated upon plate xiii, fig. 21, of his Silurian Monograph, shows that it was erect, though it appears to have been broken at the point of bifurcation; the short spiniform crura are also very distinctly seen, and upon careful examination of the specimens short dental plates can be seen in the pedicle-valve. The exterior of the shell, however, is very peculiar in its bilateral asymmetry, the existence of a sinus on each valve, and in the broad free frills at the concentric growth-lines.* In respect to its asymmetry the species, as already observed, bears very much the same relation to Triplecia as the *Mimulus Waldronensis*, from the Niagara fauna in Indiana, does to typical forms of the genus Mimulus. The combination of these features with the surface ornamentation, and the very small size of the species, will form a valid ground for the recognition of Streptis as a group subordinate to Triplecia.

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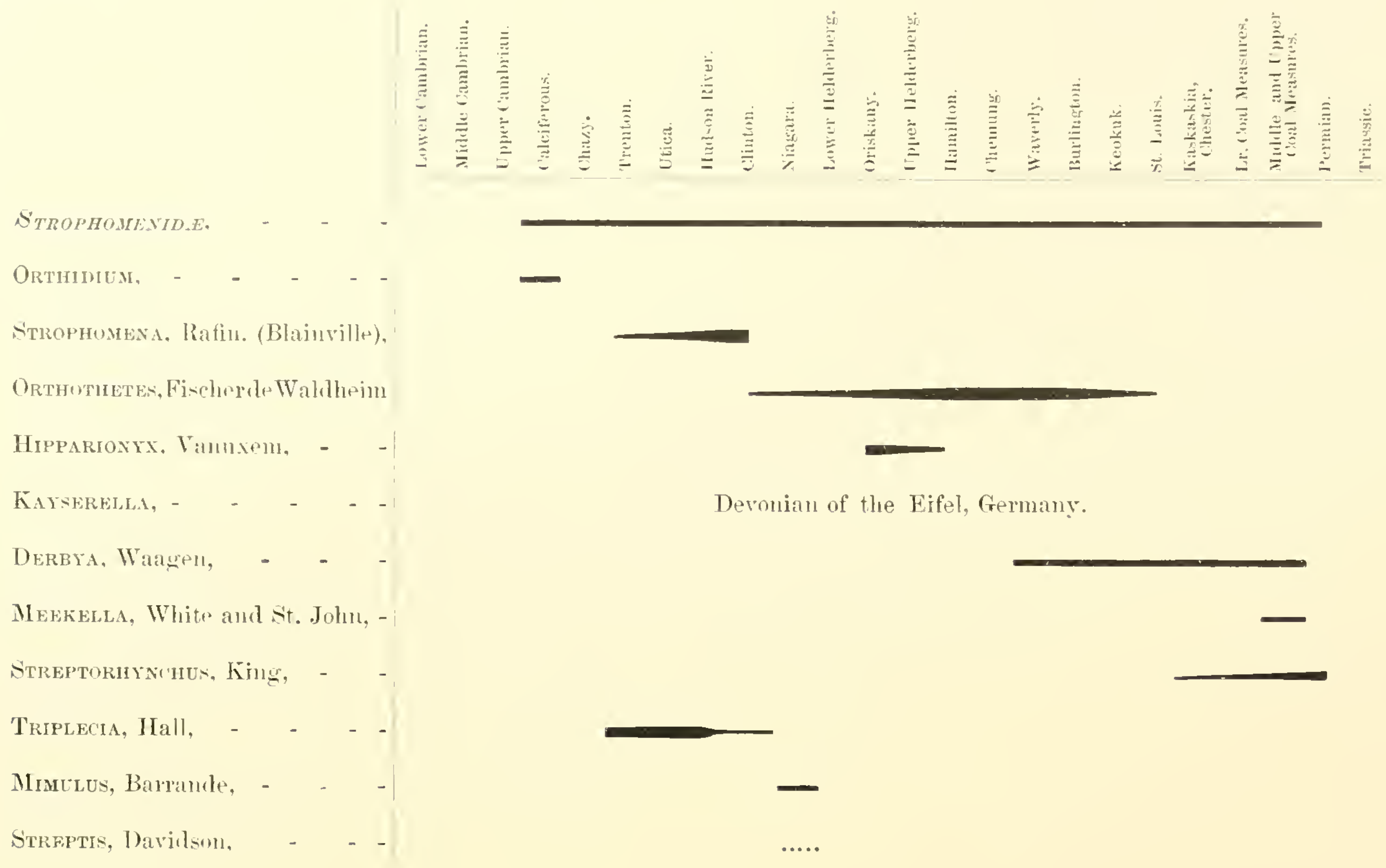
* This feature is more extravagantly developed in the Bohemian species according to the figures given by Barrande (Système Silurien, vol. v, pl. 83, figs. 2, 3 a, 3 d), than in the English forms figured by Davidson. The Bohemian specimens are from Etage E_2.


Lower Cambrian.
Middle Cambrian.
Upper Cambrian.
Calciferous.
Chazy.
Trenton.
Utica.
Hudson River.
Clinton.
Niagara.
Lower Helderberg.
Oriskany.
Upper Helderberg.
Hamilton.
Chemung.
Waverly.
Burlington.
Keokuk.
St. Louis.
Kaskaskia, Chester.
Lr. Coal Measures.
Middle and Upper Coal Measures.
Permian.
Triassic.
STROPHOMENIDÆ.
ORTHIDIUM.
STROPHOMENA, Rafin. (Blainville),
ORTHOTHETES, Fischer de Waldheim
HIPPARIONYX, Vanuxem,
KAYSERELLA,
Devonian of the Eifel, Germany.
DERBYA, Waagen,
MEEKELLA, White and St. John,
STREPTORHYNCHUS, King,
TRIPLECIA, Hall,
MIMULUS, Barrande,
STREPTIS, Davidson,

GENUS LEPTÆNA, DALMAN. 1828.

PLATE VIII, FIGS. 12-31; AND PLATE XV A, FIGS. 40-43.

1769. *Conchites*, WILCKENS. Nachricht von seltenen Verstein., p. 77, pl. viii, figs. 43, 44.
1821. *Anomites*, WAHLENBERG. Nova Acta Soc. Sci. Upsalæ, vol. viii, p. 65.
1823. *Producta*, SOWERBY. Mineral Conchology, p. 86, pl. cccclix, fig. 3.
1826. *Producta*, HISINGER. Acta Acad. Sci. Holm, p. 333.
1828. *Leptæna*, DALMAN. Uppställning och Beskrifning af de i Sverige funne Terebratuliter; Kongl. Vetenskaps-Academiens Handlingar, för ar 1827, pp. 94–96, 106, 107, pl. i, figs. 1, 2.
1834. *Leptæna*, KLÖDEN. Die Verstein. der Mark Brandenburg, p. 180.
1837. *Orthis*, VON BUCH. Ueber Delthyris oder Spirifer und Orthis, p. 30.
1837. *Leptæna*, HISINGER. Lethæa Suecica, p. 69, pl. xx, figs. 2, 3.
1837. *Leptæna*, FISCHER DE WALDHEIM. Oryctogr. du Gouv. de Moscou, p. 143.
1839. *Leptæna*, J. DE C. SOWERBY. In Murchison's Silurian System, pp. 623, 636, pl. xii, fig. 2.
1840. *Orthis*, VON EICHWALD. Silurische Schichten-System von Esthland, p. 162.
1841. *Leptæna*, PHILLIPS. Palæoz. Foss. Cornwall, Devon and West Somerset, p. 51, pl xxiv, fig. 95.
1841. *Strophomena*, CONRAD. Fifth Ann. Rept. N. Y. Geological Survey, p. 54.
1842. *Leptæna*, DE KONINCK. Descr. Anim. Foss. dans le Terr. Carbonif. Belgique.
1842. *Strophomena*, VANUXEM. Geology of N. Y.; Rept. Third Dist., pp. 79, 139, fig. 53.
1843. *Strophomena*, HALL. Geology of N. Y.: Rept. Fourth District, pp. 77, 104, fig. 52; p. 175, fig. 3.
1843. *Productus?*, DE CASTELNAU. Essai sur le Système Silurien de l'Amérique Septentrionale, p. 39, pl. xiii, fig. 7.
1844. *Orthis*, F. RŒMER. Das Rhein. Uebergangsgebirge, pp. 85, 90.
1844. *Leptagonia*, McCOY. Synopsis Carb. Foss. Ireland, p. 116.
1845. *Leptæna*, DE VERNEUIL. Géol. Russie de l'Europe et des Mont. de l'Oural, p. 234, pl. xv, fig. 7.
1846. *Leptæna*, KING. Annals and Magazine Natural History, vol. xvii, pp. 28, 36.
1847. *Leptæna*, DAVIDSON. London Geological Journal, p. 54, pl. xii, figs. 12–16.
1847. *Leptæna*, HALL. Palæontology of N. Y., vol. i, p. 108, pl. xxxi A, fig. 4.
1848. *Leptæna*, DAVIDSON. Bull. Soc. Géol. de France, Ser. 2, vol. v, p. 306, pl. iii, fig. 3.
1848. *Productus*, DAVIDSON. Bull. Soc. Géol. de France, Ser. 2, vol. v, p. 315, pl. iii, fig. 1.
1850. *Leptæna*, KING. Monograph Permian Fossils of England, pp. 81, 104.
1852. *Leptæna*, HALL. Palæontology of N. Y., vol. ii, pp. 62, 257, pl. xxi, fig. 8; pl. liii, fig. 6.
1856. *Strophomena*, BILLINGS. Canadian Nat. and Geol., vol. i, p. 59, pl. i, fig. 5.
1857. *Strophomena*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 55.
1859. *Leptæna*, VON EICHWALD. Lethæa Rossica, vol. i, p. 867.
1859. *Leptæna*, HALL. Twelfth Rept. N. Y. State Cab. Nat. Hist., p. 82.
1859. *Strophomena*, HALL. Palæontology of N.Y., vol. iii, p. 195, pl. xix, fig. 1; p. 417, pl. xciv, figs. 2, 3.
1860. *Strophomena*, F. RŒMER. Silurische Fauna westlichen Tennessee, p. 66, pl. v, fig. 2.
1861. *Strophomena*, BILLINGS. Canadian Journal, vol. vi, p. 336, figs. 111, 112.
1863. *Strophomena*, BILLINGS. Geology of Canada, p. 311, fig. 314; p. 367, fig. 373.
1863. *Strophomena*, BILLINGS. Proc. Portland Soc. Nat. Hist., p. 107, pl. iii, fig. 1.
1865. *Leptæna*, SHALER. Bull. No. 4, Mus. Comp. Zool., p. 65.
1867. *Strophomena*, HALL. Palæontology N.Y., vol. iv, p. 76, pl. xii, fig. 16–18; p. 414, pl. xv, figs. 15, 16.
1868. *Strophomena*, MEEK and WORTHEN. Geology of Illinois, vol. iii, p. 426, pl. x, fig. 7.
1873. *Strophomena*, MEEK. Palæontology of Ohio, vol. i, p. 75, pl. v, fig. 6.
1874. *Strophomena*, BILLINGS. Palæozoic Fossils, vol. ii, p. 27.
1874. *Strophomena*, JAMES. Cincinnati Quart. Jour. Sci., vol. i, p. 333.
1875. *Strophomena*, MILLER. Cincinnati Quart. Jour. Sci., vol. ii, p. 55.

1875. *Strophomena*, WHITE. Geographical and Geological Exploration West 100th Meridian, p. 85, pl. v, fig. 5.
1877. *Strophomena*, HALL and WHITFIELD. Geol. Expl. 40th Parallel, vol. iv, p. 253, pl. iv, fig. 4.
1877. *Plectambonites*, DALL. Bull. No. 8, U. S. Nat. Museum, p. 56.
1879. *Strophomena*, HALL. Twenty-eighth Rept. N.Y. State Mus. Nat. Hist., p. 151, pl. xxii, figs 4–10.
1882. *Strophomena*, HALL. Eleventh Rept. Indiana State Geologist, p. 288, pl. xxii, figs 4–10.
1883. *Strophomena*, HALL. Rept. N. Y. State Geologist for 1882, pl. xxxviii, figs. 12–31.
1884. *Strophomena*, WALCOTT. Palæontology Eureka District, p. 118.
1887. *Plectambonites*, ŒHLERT. Fischer's Manuel de Conchyliologie; Brachiopoda, p. 1285.
1889. *Strophomena*, BEECHER and CLARKE. Mem. N. Y. State Mus. Nat. Hist., vol. i, No. 1, p. 18, pl. ii, figs. 1–13.
1889. *Strophomena*, NETTELROTH. Kentucky Fossil Shells, p. 150, pl. xviii, figs. 1–3.

DIAGNOSIS:

"Testa subæquivalvis, æquilatera, complanata, margine compresso flexo.

"Margo cardinalis transversalis, rectilineus, latissimus, foramine destitutus.

"Valva altera dentibus cardinalibus duobus obtusis."—DALMAN, *op. cit.*, p. 94.

Shells plano-convex when young, concavo-convex at maturity; convexity normal. Surface covered by conspicuous concentric corrugations or wrinkles over the flatter portions of the valves. Where these cease the surface is more or less abruptly and often rectangularly deflected, forming a conspicuous anterior slope. The whole exterior is covered with fine, even, radiating, thread-like, tubular striæ, which, in well preserved specimens, are crenulated by finer concentric striæ. Outline transversely subquadrate or semioval. Hinge-line straight, its length making the greatest diameter of the shell; extremities often subauriculate. Cardinal area narrow, slightly wider on the pedicle-valve, not denticulate. In the pedicle-valve, the delthyrium is covered by a convex deltidium, perforated at the apex by a foramen which is closed at maturity or encroaches upon the apex of the valve. This deltidium is most conspicuously developed in early stages of growth, then having the form of a tube or sheath, which character becomes obliterated as maturity approaches, by the increase in the size of the cardinal process of the opposite valve, and the callosity formed about its base. In adult shells the foramen has become enclosed by the substance of the shell, its external opening being an oblique groove in front of the apex of the valve, and its inner aperture appearing in front of the pedicle-scar. Not infrequently the passage is closed at maturity. The teeth are very divergent and quite conspicuous, generally supported by lamellæ

which are continued around the subcircular muscular area of the narrow umbonal cavity. The muscular scars consist of a narrow median or adductor, enclosed by flabelliform diductors.

In the brachial valve the area is linear, the delthyrium is progressively filled by the growth of a callosity, which is often deeply grooved along the center, and sometimes perforated in the line of division between the branches of the cardinal process. The cardinal process consists of two sessile, diverging apophyses which have broad, flat, striated surfaces of attachment, and are extended beyond the hinge-line. The sockets are moderately deep; the crural plates are usually not sharply defined, but are continued in a curving line along the inner surface of the valve, partially embracing a pair of broad, ovate muscular impressions which are marked by arborescent ramifications; recurving and again incurving, these ridges partially surround a pair of smaller muscular areas, lying in front of the first. At the inner base of each branch of the cardinal process there arises a low elevation or callosity, which, extending obliquely forward, and uniting in the center, continues as a narrow median ridge dividing the posterior pair of muscular impressions. This ridge sometimes terminates in a point near the base of the first pair of impressions, and the second pair are separated by a low, slender median septum, which sometimes apparently takes its origin at this point, but which is in fact a continuation from the interrupted posterior ridge, and extends for some distance over the pallial region.

The muscular area, when its features are most distinctly retained, shows a subdivision into the following scars: (*a*) A large posterior pair (the posterior adductors), the surface of which is covered with arborescent ridges; the anterior portion of each of these scars is smoother than the rest, generally much thickened and often extremely elevated at its outer margins. These may be regarded as accessory elements of the posterior adductors. (*b*) An anterior pair (anterior adductors), situated close together at about the center of the valve. The position of these is generally well defined but their outline is frequently obscure. (*c*) An elongate, narrow median scar, which is apparently divided for its entire length by a faint ridge. In front of the muscular area there are often a number of short protuberances on each side of the median

septum, and the anterior pair of scars is frequently obliterated by prominent callosities. At the line of geniculation the interior surface is elevated into a very prominent, sharp, or abruptly rounded crest. Spiral callosities for the support of the brachia, similar to those in Davidsonia and Leptænisca, have been observed by Dr. Davidson.

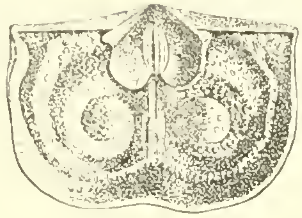


Fig. 18. *Leptæna rhomboidalis*, showing impressions of spiral arms After Davidson.

Shell-substance strongly punctate.

Type, *Leptæna rugosa*, Dalman = *Producta rugosa*, Hisinger = *Conchites rhomboidalis*, Wilckens. Upper Silurian.

Observations. Having already given at some length the reasons for restricting the application of the term Strophomena, Rafinesque, as defined and illustrated by de Blainville, the genus Leptæna, of Dalman, will be left to rest upon its first and typical species, *Producta rugosa*, Hisinger. This is precisely the interpretation of the genus followed by most authors from 1830 to 1860 Prof. King, in the Annals and Magazine of Natural History, 1846, and in his Monograph of the Permian Fossils of England, 1850, proposed restricting the genus more narrowly than heretofore, including only "such shells as *L. analoga*, Phill., *L. semiovalis*, McCoy, *L. plicotis*, McCoy, *L. nodulosa*, Phill., and *L. multirugata*, McCoy" (Permian Fossils, p. 104). All these are of the type of *L. rhomboidalis*. During the early part of this period Strophomena, as already pointed out in the discussion of that genus, was a term of uncertain value.

Dalman placed under his genus Leptæna four species, in the following order: *L. rugosa*, Hisinger, *L. depressa*, Sowerby, *L. euglypha*, Dalman, *L. transversalis*, Wahlenberg. The same author observed that the first two of these had been included by Wahlenberg, in 1821, under the name *Anomites rhomboidalis*, this specific term having been first used by Wilckens, in 1769. The other two species are not congeneric with *L. rhomboidalis*. Davidson, however, regarding the first three as proper Strophomenas (1853–1884), decided to take the last species, *L. transversalis*, as the type of Leptæna, and it is this use of the term that has become current among palæontologists. Were it necessary, however, to reject the first two of Dalman's species, the third, *L. euglypha*, a member of the genus Strophonella, Hall, 1879, would have to stand as the type of Lep-

tæna. In 1844, McCoy, having proposed to apply the term Leptæna to species of Productus or Chonetes or both, suggested a new term, Leptagonia, for shells like *Producta analoga*, Phillips = *Leptæna rhomboidalis.**

There are sufficient reasons for limiting the application of the term Leptæna to shells conforming precisely to the structure exhibited by *L. rhomboidalis.* Dr. Davidson, in his later years, was evidently convinced of the validity of this group.† Whether *L. rhomboidalis* shall be allowed to include all the forms from Silurian to Carboniferous faunas which have the characters given in the foregoing diagnosis, or whether the numerons specific and varietal names that have been proposed shall be recognized in whole or part will depend upon one's conception of specific values. At all events the type of internal structure accompanied by the peculiar corrugated and geniculated exterior has proved a very compact and resistant combination, a fact evinced by the mere possibility of a question arising as to the specific identity of the various forms. It is worthy of note that among the American representatives of this type of structure which have been studied, the extreme differentiation of the muscular area as described is even more distinctly exhibited in the forms of the early Carboniferous than in those of the Silurian and Devonian.

Believing that it will serve a good purpose in the taxonomy of these organisms to thus restrict the generic term Leptæna to this peculiar group of forms, it will become necessary to arrange under another designation the much more abundantly developed "Strophomenas" of the Silurian, exemplified by *Leptæna alternata* of Conrad. These differ essentially from *L. rhomboidalis*, not in their exterior features alone, but also in their interior characteristics; and there is no name among all those which have been suggested or superceded which is applicable, or can be legitimately used, and therefore it becomes necessary to propose a new generic term.

* De Verneuil, in 1845, proposed a classification of the species then referred to this genus, on the basis of their superficial ornamentation. His conception of the genus is expressed in his own words: "Nous proposons de rendre au genre Leptæna, sa valeur primitive, en y réunissant toutes les coquilles plus ou moins analogues à celles que Dalman avait ainsi nommées" (Géologie de la Russie, etc., p. 215). We therefore find in his list of twenty-three species not only the various types of structure given by Dalman, but some others.

† See General Summary, p. 379.

GENUS RAFINESQUINA, GEN. NOV.

LEPTÆNA and STROPHOMENA of most authors.

PLATE VIII, FIGS. 1-11; PLATE IXA, FIGS 1, 2, 4; AND PLATE XVA, FIGS. 37, 38, 39 (?).

1838. *Leptæna*, CONRAD. Second Ann. Rept. N. Y. Geological Survey, p. 115.
1839. *Strophomena*, CONRAD. Third Ann. Rept. N. Y. Geological Survey, pp. 63, 64.
1840. *Strophomena*, CONRAD. Fourth Ann. Rept. N. Y. Geological Survey, p. 201.
1841. *Strophomena*, CONRAD. Fifth Ann. Rept. N. Y. Geological Survey, p. 37.
1842. *Strophomena*, CONRAD. Jour. Acad. Nat. Sci. Phil., vol. viii. p. 254, pl. xiv, fig. 5; pp. 259, 260.
1842. *Strophomena*, VANUXEM. Geological Rept. Third Dist. N. Y., p. 46, fig. 2.
1842. *Strophomena*, EMMONS. Geol. Rept. Second Dist. N.Y., p. 389, fig. 2; p. 395, fig. 3; p. 403, fig. 3.
1843. *Orthis*, DE CASTELNAU. Essai sur le Système Silurien de l'Amérique septentrionale, pp. 37, 38, pl. xiv, figs. 1, 6.
1844. *Strophomena*, OWEN. Geol. Expl. Iowa, Wisconsin, and Illinois, pl. xvi, fig. 8; pl. xvii, fig. 6.
1847. *Leptæna*, HALL. Palæontology of N. Y., vol. i, p. 19, pl. iv (bis), fig. 2; p. 20, pl. iv (bis), fig. 3; p. 102, pl. xxxi, fig. 1, pl. xxxi A, fig. 1; pp. 106, 107, pl. xxxi A, figs. 2, 3; p. 109, pl. xxxi B, fig. 1; p. 115, pl xxxi B, fig. 8; p. 286, pl. lxxix, fig. 2.
1852. *Leptæna*, HALL. Palæontology of N. Y., vol. ii, p. 62, pl. xxi, fig. 6.
1856. *Strophomena*, BILLINGS. Canadian Nat. and Geol., vol. i, p. 214, figs. 3, 4.
1858. *Strophomena*, ROGERS. Geology of Pennsylvania, vol. ii, p. 817, fig. 591; p 818, fig. 600.
1859. *Strophomena*, HALL. Twelfth Rept. N. Y. State Cab. Nat. Hist., p. 70.
1859. *Strophomena*, BILLINGS. Canadian Nat. and Geol., vol. iv, p. 443.
1860. *Strophomena*, BILLINGS. Canadian Nat and Geol., vol. v, pp. 51-54, fig. 1.
1862. *Strophomena*, BILLINGS. Palæozoic Fossils, vol. i, pp. 117, 118, fig. 97; pp. 119, 128, fig. 106.
1863. *Strophomena*, BILLINGS. Canadian Geology, Report of Progress, p. 163, fig. 140; pp. 141, 209, fig. 208.
1865. *Strophomena*, SHALER. Bulletin Mus. Comp. Zoology, No. 4, p. 62.
1868. *Strophomena*, MEEK and WORTHEN. Geological Survey of Illinois, vol. iii, p. 335, pl. iv, fig. 11.
1871. *Strophomena*, DAVIDSON. British Silurian Brachiopoda, p. 285, pl. xlii, figs. 20, 21; p. 292, pl. xlii, figs. 1-5; pl. xxxix, figs. 22-24; p. 296, pl. xxxvli, figs. 23-26; pl. xlii, figs. 6-8; p. 383, pl. xlii, figs. 18, 19; pl. xlvii, figs. 1-4; pp. 310, 311, pl. xlii, fig. 11; pl. xliii, fig. 15; p. 312, pl. xlv, figs. 1-10.
1873. *Strophomena*, MEEK. Palæontology of Ohio, vol. i, pp. 88-91, pl. vii.
1874. *Strophomena*, MILLER. Cincinnati Quart. Jour. Sci., vol. i, p. 13.
1874. *Strophomena*, JAMES. Cincinnati Quart. Jour. Sci., vol i, p. 335.
1875. *Strophomena*, MILLER. Cincinnati Quart. Jour. Sci., vol. ii, pp. 51-54.
1881. *Strophomena*, N. H. WINCHELL. Ninth Annual Rept. State Geologist of Minnesota, p. 120.
1881. *Strophomena*, WHITE. Tenth Ann. Rept. Indiana State Geol., p. 113, pl. i, figs. 6, 7.
1882. *Strophomena*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 261, pl xii, figs. 15, 16; p. 262, pl. xii, fig. 14.
1883. *Strophomena*, DAVIDSON. British Silurian Brachiopoda, Suppl., p. 193, pl. xvi, figs. 6, 7.
1883. *Strophomena*, HALL. Report N. Y. State Geologist for 1882, pl. xxxviii, figs. 1-11.
1887. *Strophomena*, SHALER. Memoirs Kentucky Geol. Survey, p. 4, pls. ii, iii.

DIAGNOSIS. Shells normally concavo-convex. Surface ornamented by radiating striæ, of alternating size, crossed and crenulated by finer concentric striæ. Cardinal margins without denticulations. Interior of the pedicle-valve

with the muscular area not strongly limited; consisting of two broad flabellate diductor scars enclosing an elongate, more distinctly defined adductor. The faintness of the limitation of this area is in marked contrast to the sharply defined muscular area in the corresponding valve of LEPTÆNA. In the brachial valve the cardinal process is more closely sessile than in LEPTÆNA, and there is frequently a linear callosity between the branches. The posterior adductor scars have the arborescent markings of *Leptæna rhomboidalis*, and these impressions are the only ones well defined, the anterior scars being narrow and rarely retained with distinctness. From the anterior margin of the muscular area radiates a series of irregular furrows and nodose ridges, which are to some extent of vascular origin.

Type, *Leptæna alternata*, Conrad. Trenton and Hudson River groups.

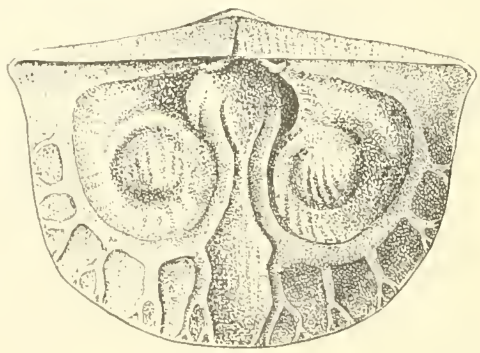


FIG. 19. *Rafinesquina Jukesi*, showing the brachial ridges. After DAVIDSON.

OBSERVATIONS. There are some shells, a small number of species however, which combine to some extent the characters of both LEPTÆNA and RAFINESQUINA. We may instance *Leptæna deltoidea*, Conrad, and *Strophomena unicostata*, Meek and Worthen, in which there are not only low, concentric corrugations on the exterior, but in the latter species the interior of the brachial valve has more distinctly the impress of LEPTÆNA than of RAFINESQUINA. There are concentrically wrinkled species in the genera STROPHOMENA, STROPHEODONTA and STROPHONELLA, but that character will prove of little value except for a subsidiary grouping of species. The extravagant development of this feature

in *Leptæna rhomboidalis*, persisting throughout so many successive faunas, forms one of the substantial reasons for the separation of that form from its allies.

The leptænoid type of structure attained its most abundant exemplification in the faunas of the Silurian. *Leptæna rhomboidalis*, which appeared in the Trenton and Caradoc has alone carried this type onward through the Upper Silurian, the Devonian and into the Lower Carboniferous. RAFINESQUINA is represented by a number of species in American faunas, *e.g.*, *Leptæna fasciata*, Hall, of the Chazy; *L. alternata*, Conrad, *L. alternistriata*, Hall, *L. deltoidea*, Conrad, *Strophomena camerata*, Conrad, and *Leptæna incrassata*, (Hall) Safford, of the Trenton; *S. Minnesotensis*, N. H. Winchell, *S. Kingi*, Whitfield, *S. nitens*, Billings, *Leptæna alternata*, Conrad, *Strophomena squamula* and *S. Ulrichi*, James, from the Hudson River group.

In the Clinton fauna the *Leptæna obscura*, Hall, may belong to this group, and if so is probably its latest representative in our faunas. In the Silurians of Great Britain the best developed representation of these fossils is in the Caradoc fauna (*Leptæna* (*Leptagonia*) *ungula*, McCoy, *L. deltoidea*, Conrad, *Strophomena Jukesi*, Davidson, *S. Holli*, Davidson, *S. siluriana*, Davidson, *Orthis expansa*, Sowerby). There are a number of species in the Wenlock which appear to belong to this group, such as *Orthis Orbignyi*, *Leptæna Waltoni* and *Strophomena Hendersoni*, Davidson.

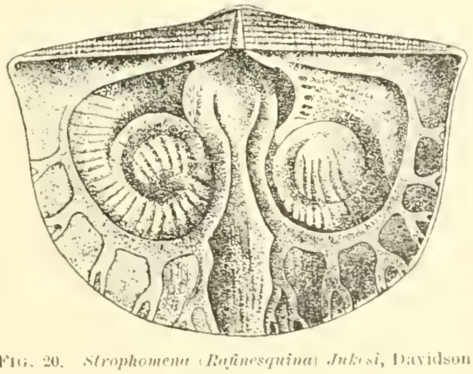


FIG. 20. *Strophomena* (*Rafinesquina*) *Jukesi*, Davidson
After DAVIDSON.

Genus STROPHEODONTA, Hall. 1852.*

PLATE XIII, FIGS. 1-28, PLATE XIV, FIGS. 1-23; PLATE XV, FIGS. 2-21; AND PLATE XVB, FIGS. 1-9.

1830. *Plectambonites*, Pander (*partim*). Beitr. zur Geognosie des russ. Reich., p. 91, pl. xix, fig. 12.
1838. *Leptæna*, Conrad. Second Ann. Rept. N. Y. Geological Survey, pp. 112, 117.
1839. *Orthis*, Sowerby. Murchison's Silurian System, pl. xiii, fig. 12; pl. xxii, fig. 12.
1841. *Orthis*, Phillips. Palæoz. Foss. Cornwall, Devon and West Somerset, p. 61, pl. xxv, fig. 103.
1842. *Strophomena*, Conrad. Journ. Acad. Nat. Sci. Phila., vol. viii, pp. 254-259, pl. xiv, figs. 2, 3, 6, 7, 10, 11, 14, 19.
1842. *Strophomena*, Vanuxem. Geology of N. Y.; Rept. Third District, p. 174, fig. 1.
1843. *Strophomena*, Hall. Geology of N. Y.; Rept. Fourth District, p. 104, fig. 3; p. 171, fig. 4; p. 200, fig. 4; p. 266, figs. 1, 5.
1845. *Leptæna*, de Verneuil. Géol. Russ. et des Mont. de l'Oural, p. 220, pl. xiv, fig. 1; p. 223, pl. xiv, fig. 2; p. 224, pl. xiv, figs. 3, 4; p. 230, pl. xv, fig. 3.
1846. *Orthis*, McCoy. Synopsis Silurian Fossils Ireland, p. 30.
1848. *Leptæna*, Davidson. Bull. Soc. Géol. de France, Ser. 2, vol. v, p. 318, pl. iii, fig. 9.
1848. *Orthis*, *Strophomena*, Phillips and Salter. Mem. Geological Surv. United Kingdom, vol. ii, pp. 288, 379.
1852. *Leptæna*, *Stropheodonta*, Hall. Palæontology of N. Y., vol. ii, pp. 61, 63, pl. xxi, figs. 4, 5, 9; p. 327, pl. lxxiv, fig. 6.
1852. *Strophodonta*, Owen. Geol. Surv. Wisconsin, Iowa and Minnesota, pp. 584, 585.
1853. *Leptæna*, Schnur. Beschr. Eifel vorkomm. Brachiopoden, pp. 222-224, pl. xxxix, fig. 5; pl. xli, figs. 1, 3, 6; pl. xlii, figs. 3, 4.
1857. *Strophomena* (*Strophodonta*), Hall. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 52-55, 111, 113-115, 137-145.
1858. *Strophomena*, Rogers. Geology of Pennsylvania, vol. ii, p. 827, figs. 665, 666.
1858. *Strophodonta*, Hall. Geol. Surv. Iowa, vol. i, pt. ii, pp. 491-493, 495, 496, pl. iii, figs. 1-3, 5, 6.
1859. *Strophodonta*, Hall. Palæontology of N.Y., vol. iii, pp. 180-184, 191, 194, 411-415, 482, pl. viii, figs. 2-16; pl. xvi, figs. 1-14; pl. xviii, fig. 1; pl. xxii, fig. 1; pl. xcii, figs. 2-4; pl. xciii, figs. 2-4; pl. xciv, figs. 2, 3; pl. xcv, figs. 8-10; pl. xcv A, figs. 13-19.
1860. *Strophodonta*, Swallow. Trans. St. Louis Acad. Sci., vol. i, pp. 635-639.
1860. *Strophodonta*, Hall. Thirteenth Rept. N. Y. State Cab. Nat. Hist., p. 90.
1861. *Strophomena*, Billings. Canadian Journal, 2nd Ser., vol. vi, p. 338, fig. 113; p. 340, figs. 116-118; pp. 341, 343, 344, 348, 349.
1863. *Strophomena*, Billings. Geology of Canada, p. 367, figs. 374, 375, 377; p. 961, figs. 468, 469.
1863. *Strophodonta*, Hall. Sixteenth Rept. N. Y. State Cab. Nat. Hist., pp. 36, 37.
1863. *Strophomena*, Billings. Proc. Portland Soc. Nat. Hist., p. 109, pl. iii, fig. 3.
1865. *Strophomena*, Billings. Palæozoic Fossils, vol. i, pp. 120, 122, figs. 98-101.
1865. *Leptæna*, Davidson. British Devonian Brachiopoda, p. 85, pl. xviii, figs. 15-18.
1865. *Strophomena*, Winchell and Marcy. Memoirs Boston Soc. Nat. Hist., vol. i, p. 92, pl. ii, fig. 9.
1865. *Strophodonta*, Meek. American Journal Science, vol. xl, p. 33.
1866. *Strophodonta*, Winchell. Rept. Lower Penin. Michigan, p. 93.
1867. *Strophodonta*, Hall. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 369, pl. xiii, fig. 34.
1867. *Strophodonta*, Hall. Palæontology N.Y., vol. iv, pp. 81-93, 96-111, 113, 114, pls. xi; xii, figs. 1-15; xiii; xiv, fig. 2; xv, figs. 1-14; xvi; xvii; xviii; xix, figs. 1-5, 8-19.
1868. *Strophodonta*, Meek. Trans. Chicago Acad. Sci., vol. i, pp. 87, 88, pl. xiii, figs. 6, 7.
1871. *Strophomena*, Davidson. British Silurian Brachiopoda, pp. 286, 307, 309, 315, pl. xli, figs. 1-6; pl. xliii, figs. 16-20; pl. xlvi, figs. 7-10.

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* Stropheodonta, "Gr. στροφευς, *cardo*, and οδους, *dens*." This term has come into general use with the form Strophodonta, which has a different etymology. It may be well to adhere to the original form of the word as more appropriate in its application to these shells.

1871. *Strophomena*, KAYSER. Zeitschrift der deutsch. geolog. Gesellschaft, vol. xxiii, pp. 620, 621, 624, 625, 627, 630, pl. xiv, figs. 4, 5.
1872. *Strophomena*, BARRANDE. Système Silurien du Centre de la Bohême, pl. xl, figs. 10–19; pl. xlii, figs. 6–14, 21–28; pl. xliii, figs. 1–5, 17–29; pl. xliv, figs. 1–30.
1873. *Strophodonta*, HALL and WHITFIELD. Twenty-third Rept. N. Y. State Cab. Nat. Hist., pp. 236, 239, pl. xi, figs. 8–11.
1873. *Strophodonta*, NICHOLSON. Rept. Palæontology Province of Ontario, pp. 64, 65, 67.
1874. *Strophomena*, BILLINGS. Palæozoic Fossils, vol. ii, pp. 20, 24, 26–29.
1877. *Strophodonta*, HALL and WHITFIELD. King's Expl. and Surv. Fortieth Parallel, vol. iv, p. 246, pl. iii, figs. 1–3.
1878. *Strophodonta*, CALVIN. Bulletin No. 3, United States Geological Survey, vol. iv, pp. 727, 728.
1878. *Strophodonta*, BARRETT. American Journal of Science vol. xv, p. 372.
1879. *Strophodonta*, HALL. Twenty-eighth Rept. N.Y. State Mus. Nat. Hist., p. 151, pl. xxiii, figs. 9, 10.
1880. *Strophomena*, DAWSON. Canadian Naturalist and Geologist, 2nd Ser., vol. ix, p. 341.
1881. *Strophodonta*, WHITE. Tenth Rept. Indiana State Geologist, p. 132, pl. iv, figs. 6, 7.
1881. *Strophomena*, DAVIDSON. Brachiopoda Budleigh-Salterton Pebble-bed, pp. 348–351, pl. xxxix, figs. 1, 2, 4–11.
1882. *Strophodonta*, HALL. Eleventh Ann. Rept. State Geologist Indiana, p. 289, pl. xxiii, figs. 9, 10; pl. xxvii, fig. 18.
1882. *Strophodonta*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 327, pl. xxv, fig. 18.
1883. *Strophodonta*, HALL. Ann. Rept. N. Y. State Geologist for 1882, pls. xiii (44); xiv (45); xv (46), figs. 1–24.
1884. *Strophodonta*, WALCOTT. Palæontology Eureka Dist., pp. 118–122, pls. ii, xi, xiii.
1889. *Strophodonta*, NETTELROTH. Kentucky Fossil Shells, pp. 142–150.
1889. *Strophomena*, BARROIS. Faune du Calcaire d'Erbray, pp. 63–65, 67, pl. iv, figs. 6, 8–10.

DIAGNOSIS. Shells normally concavo-convex or subplano-convex. Cardinal area common to the two valves, that of the brachial valve narrower or linear; smooth or finely striated longitudinally, sometimes showing through the outer laminæ of the shell strong, parallel, transverse bars, which project beyond the cardinal margin as short processes, and articulate with a corresponding series of pits in the opposite valve. The earliest species have these denticulations developed only for a short distance on each side of the center, while in the latter faunas they extend the entire length of the hinge-line. In the type-species the delthyrium is usually completely closed by the extension of the shelly laminæ of the area, and on the inside by the formation of a callosity between the apophyses of the cardinal process. Sometimes a low, narrow, convex deltidium is present, but in the early species the delthyrium is frequently open.

From the normal position of the dental lamellæ there extend two diverging, sometimes nearly vertical, ridges of variable strength, bounding the post-lateral portion of the muscular area, which is not limited by a ridge in front. The entire muscular area consists of two broad flabelliform diductor scars, enclosing an oval adductor which is distinctly divided into anterior and posterior ele-

ments. The foramen, dental plates and teeth are obsolete or obsolescent in the Devonian species.*

In the brachial valve the delthyrium is also usually closed; the cardinal apophyses are strongly arched into the umbonal cavity of the opposite valve, their surfaces of attachment being sometimes nearly parallel to the plane of the cardinal area of the brachial valve, and often extending beyond it. Small crural plates are always present, though they could not have been functional at maturity. Muscular arrangement similar to that of *Leptæna rhomboidalis* and *Rafinesquina alternata*, the posterior scars being more elongate, the anterior pair usually less defined, and all the scars frequently obscured. The anterior muscular fulcra are sometimes developed into very prominent elongate apophyses. The median septum often becomes elevated into a high crest at the center of the valve. Over the pallial region the interior of both valves is strongly papillose. External surface covered with radiating, sometimes fasciculate striæ; rarely smooth. Shell-substance fibrous, coarsely punctate.

Type, *Leptæna demissa*, Conrad. Hamilton group.

OBSERVATIONS. The distinctive characters of this genus are clearly evident, but notwithstanding its importance, both zoologically and geologically, it has never been accorded general recognition except among American writers. Mr. BILLINGS would not admit its validity; Dr. DAVIDSON barely noticed the term; Professor KAYSER and the German writers generally continue to refer its species to STROPHOMENA (= STROPHOMENA, LEPTÆNA, RAFINESQUINA, etc.); Dr. ŒHLERT has adopted it, making it a sub-genus of STROPHOMENA, Rafinesque (de Blainville), while he proposes a new genus, DOUVILLINA, which is essentially synonymous. The genus STROPHEODONTA is a large one, being represented in American faunas by not less than fifty species, and it is emphatically characteristic of the Devonian. It makes its first appearance in the Clinton group, having a sparse representation in the Niagara, but becomes more abundant in the Lower

* The obliteration of these parts may be due to the excessive secretion of calcareous matter in the umbonal region. Where this deposit is less there remains some evidence of these features, as in *S. profunda* of the Niagara, *S. Becki* of the Lower Helderberg, and especially in *S. magnifica* of the Oriskany sandstone, one of the largest species of the genus, in which the short dental lamellæ converge and unite at the bottom of the rostral cavity, making a sort of pedicle-pit and leaving the delthyrium open. See Plate XIII, fig. 28.

Helderberg, Oriskany and throughout the Devonian, disappearing with the fauna of the Chemung group.

The Stropheodontas comprise two natural subdivisions based on the contour of the shells alone. The typical group is strongly concavo-convex, and to this belong the majority of the species which can be referred to the genus in its widest scope. Subordinate to this group of convex forms is a smaller division, exemplified by *S. nacrea*, Hall, of the Corniferous and Hamilton faunas, in which the surface is smooth, often nacreous and with a few squamous growth-lines. The entire substance of the shell is strongly punctate, the epidermal impunctate layer, which in other species preserves its usual thickness, seems here reduced to a mere film. The interior of the brachial valve bears three diverging ridges in front of the muscular area, in this respect resembling *Leptæna rhomboidalis* more than typical STROPHEODONTA. Closely allied to the species is *Strophomena lepis*, Bronn, of the Middle Devonian of the Eifel, Belgium and the Asturias.* It may be found convenient to unite these and an unnamed species from the Corniferous limestone under the term PHOLIDOSTROPHIA.

The plano-convex species of STROPHEODONTA are distinguished from the group of *S. demissa* by more than contour alone. The characters of the deltidium show the same progressive development as in the concavo-convex Stropheodontas, the earliest species having the delthyrium sometimes open, sometimes partially closed by a convex plate; while in the Devonian species the deltidium is reduced to a flat, transverse lamina, supported within by the callosity about the cardinal apophyses. In the pedicle-valve are two very strongly pustulose, diverging ridges, bounding the muscular impressions on their lateral margins, while anteriorly these scars are broadly flabelliform and not strongly limited. The central adductors are small, relatively obscure and not divisible.† Should

* Dr. ŒHLERT associates with *S. lepis*, Bronn, and *S. Narajoana*, de Verneuil (= *S. lepis*, Bronn, *teste* KAYSER), the finely striated species *S. clausa*, de Verneuil, and *S. Leblanci*, Rouault. This group, he says, forms a passage to the family PRODUCTIDÆ, in the rudimentary condition or absence of the foramen, the obsolescence of the teeth and sockets, the arrangement of the muscles, and especially, in the existence of reniform impressions (Ann. des Sciences Géologique, vol. xiv, Art. No. 1, p. 63, 1887. See pl. iv, fig. 10). KAYSER has observed a similar structure in the *Leptæna caudata*, Schnur, of the Eifel (Zeitschr. der deutsch. geol. Gesellsch., vol. xxi, p. 628).

† *S. Calvini*, Miller, and *S. Canace*, Hall and Whitfield, are convex shells with the interior characters of this group. Neither their external nor internal features are very positively developed, and these shells are excellent examples of connecting forms.

it be found desirable or important to recognize the value of the characters above indicated, these forms may be separated under the term LEPTOSTROPHIA.

As typical representatives of this group, may be taken *S. magnifica*, Hall, of the Oriskany sandstone, and *S. perplana*, Conrad, of the Corniferous, Hamilton and Chemung faunas; and of the other American representatives we may cite *S. textilis*, Hall, of the Coralline limestone, *S. Becki*, Hall, of the Lower Helderberg, *S. magniventra*, Hall, of the Oriskany, *S. Junia*, Hall, of the Hamilton, *S. Irene*, *S. Blainvillii* and *S. Tullia*, Billings, from the Lower Devonian of Gaspé. In European faunas the group is represented by *Strophomena filosa*, (Sowerby) Davidson, of the Wenlock, *S. explanata*, (Sowerby) Kayser, of the Coblenzian, *S. ? palma*, Kayser, of the Calceola beds, and *S. Steini*, Kayser, of the Wiedaerschiefer (Lower Devonian) of the Hartz

There is a small number of species, the incipient members of the genus STROPHEODONTA, in which the delthyrium is open, or but partially covered, as in some of its later forms, the crenulations are confined to a very limited extent on either side of the deltidium, and upon one of these forms, *Strophomena Leda*, Billings, from the Anticosti group, Professor SHALER has proposed to found* the genus BRACHYPRION. To the same group belong the *Strophomena Philomela*, Billings, from the *Pentamerus oblongus* beds of Anticosti, and Professor SHALER has described two other species from Anticosti, *Brachyprion ventricosum* and *B. geniculatum*. These features can scarcely be regarded as of generic value, but the group is an interesting one on account of its being the precursor of the fuller development of those characters on which the genus STROPHEODONTA was originally founded.

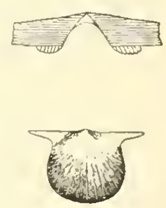

FIG. 21. *Brachyprion Leda*. After BILLINGS.

Dr. ŒHLERT has proposed the generic term DOUVILLINA,† for the species *Leptæna Dutertrii*, Murchison,‡ evidently not fully apprehending its very close

* Bulletin of the Museum of Comparative Zoology, vol. i, p. 63. 1865.

† In Fischer's Manuel de Conchyliologie; Brachiopodes, p. 1282. 1887.

‡ See DE VERNEUIL, Géologie de la Russie, etc., p. 223, pl. xiv, figs. 2 a, b, c. Fig. 4 of the same plate represents an interior closely similar to that figured by ŒHLERT, and in the explanation of plate is referred to *L. Dutertrii*, but on page 224 is regarded as belonging to *L. asella*, de Verneuil. In this case the latter

relationship to, or identity with STROPHEODONTA. In his diagnosis of the genus he describes the shell as having a crenulated hinge and flat deltidium. In the pedicle-valve are two small teeth connected with diverging ridges which are strongly elevated in front and enclose a transverse muscular area. Beneath the beak are two crests supported by a short median septum; posteriorly these all unite to form a single apophysis grooved in the middle and uniting with the inner surface of the deltidium. The brachial valve has a prominent bifid cardinal process, and a pair of small protuberances representing the crural plates; from the base of the cardinal process extends a median ridge which bifurcates anteriorly enclosing a cavity for the insertion of the anterior adductors.

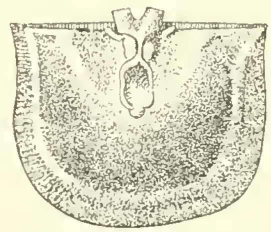

FIG. 22. Brachial valve of *Douvillina Dutertrii*. After ŒHLERT.

This division may have some value in bringing into association species having certain slight variations from the type of structure in *Stropheodonta demissa*.

A few convex species in the later Devonian (*S. inequistriata*, *S. arcuata*, *S. Cayuta*, Hall, and *S. variabilis*, Calvin*), correspond with the characters described by Dr. ŒHLERT, in having the muscular area of the pedicle-valve deepened and its edges strongly elevated. In the brachial valve the anterior myophores have the character of two diverging crests.

The genus STROPHEODONTA, though more prolific in species than RAFINESQUINA, bears much the same relation to Devonian faunas as the latter does to the Silurian. Its earliest members (BRACHYPRION) appeared while RAFINESQUINA still existed, but the advent of the typical Stropheodontas was preceded by the decline and extinction of the Rafinesquinas. This fact is true not of the American Palæozoic alone, though it is here best exemplified on account of the far greater abundance of forms belonging to both groups.

species must belong to the same group of shells. Both species occur associated in the Devonian of the Bas-Boulonnais, in France, and the environs of Voroneje, in Russia.

* This is a peculiarly variable shell exteriorly, sometimes with the convexity normal, at others with the convexity reversed nearly as in STROPHONELLA, and again the valves are at times nearly flat, as in *S. perplana*.

GENUS STROPHONELLA, HALL. 1879.

PLATE XII, FIGS. 1-21; AND PLATE XV B, FIG. 10.

1828. *Leptæna*, DALMAN. Kongl. Vetenskaps-Akadem. Handlingar, p. 108, pl. i, fig. 3.
1837. *Leptæna*, HISINGER. Lethæa Suecica, p. 69, pl. xx, fig. 4.
1838. *Leptæna*, CONRAD. Second Ann. Rept. Palæontological Dept. N. Y., pp. 112, 117.
1839. *Leptæna*, SOWERBY. Murchison's Silurian System, p. 622, pl. xii, fig. 1.
1840. *Orthis*, VON BUCH. Mem. Soc. Géol. de France, vol. iv, p. 222, pl. xii, fig. 26.
1842. *Strophomena*, VANUXEM. Geology of N. Y.; Rept Third District, p. 122, fig. 5.
1843. *Strophomena*, HALL. Geology of N. Y.; Rept. Fourth District, p. 104, fig. 3.
1846. *Orthis*, MCCOY. Synopsis Silurian Fossils Ireland, p. 30, pl. iii, fig. 11.
1847. *Leptæna*, DAVIDSON. London Geological Journal, vol. i, pp. 56, 57, pl. xii, figs. 1-8.
1852. *Leptæna*, HALL. Palæontology of N. Y., vol. ii, p. 259, pl. liii, fig. 7.
1852. *Leptæna (Strophomena)*, MCCOY. British Palæozoic Fossils, pp. 243, 244.
1857. *Strophomena (Strophodonta)*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 49-51, 53, 111, figs. 1, 2.
1858. *Strophodonta*, HALL. Geological Survey of Iowa, vol. i, pt. 2, p. 494, pl. iii, fig. 4.
1858. *Strophomena*, SCHMIDT. Silur. Format. Estland. Nord-Livl. und Oesel, p. 215.
1859. *Strophodonta*, HALL. Palæontology of N.Y., vol. iii, p. 185-190, 193, 194?, 483, pls. xvi, figs. 13, 14 (?); xviii, fig. 3; xx, figs. 1-3; xxi, figs. 1-9; xxiii, figs. 1-7.
1860. *Strophomena*, F. ROEMER. Sil. Fauna westl. Tennessee, p. 66, pl. v, fig. 3.
1861. *Strophomena*, BILLINGS. Canadian Journal, vol. vi, p 345, figs. 119, 120.
1863. *Strophomena*, BILLINGS. Proceedings Portland Soc. Nat. Hist., p. 108, pl. iii, fig. 2.
1863. *Strophomena*, BILLINGS. Geology of Canada, p. 367, figs. 376, 378.
1865. *Strophodonta*, MEEK. American Journal of Science, vol. xl, p. 33.
1867 *Strophodonta*, HALL. Palæontology of N. Y., vol. iv, pp. 93, 112, pl. xiv, figs. 1 *a-i*; pl. xix, figs. 6, 7.
1868. *Strophomena (Strophodonta)*, MEEK and WORTHEN. Geol. Illinois, vol. iii, p. 374, pl. vii, fig. 10.
1871. *Strophomena*, KAYSER. Zeitschr. der deutsch. geolog. Gesellsch., vol. xxiii, p 628, pl. xiv, fig. 3.
1871. *Strophomena*, DAVIDSON. British Silurian Brachiopoda, p. 288, pl. xl, figs. 1-5; p. 290, pl. xl, figs. 9-13.
1874. *Strophomena*, BILLINGS. Palæozoic Fossils, vol. ii, p. 31, pl. iii, fig. 2.
1879. *Strophonella, Strophodonta*, HALL. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., pp. 152, 154, pl xxii, figs. 1-3; pl. xxiii, figs. 1-8.
1879. *Strophomena*, BARRANDE. Système Silurien du Centre de la Bohême, vol. v, pl. xxxix, figs. 1-8.
1882. *Strophonella, Strophodonta*, HALL. Eleventh Rept. State Geologist Indiana, pp. 290, 292, pl. xxii, figs. 1-3; pl. xxiii, figs. 1-8.
1883. *Strophonella*, HALL. Rept. N. Y. State Geologist for 1882, pl. xii (43).
1884. *Strophodonta*, WALCOTT. Palæontology Eureka Dist., p. 121, pl. xiii, fig. 10.
1889. *Strophonella*, BEECHER and CLARKE. Mem. N.Y. State Mus., vol. i, No. 1, p. 25, pl. iii, figs. 1-8.
1889. *Strophodonta*, NETTELROTH. Kentucky Fossil Shells, p. 149.

DIAGNOSIS. "Shells semicircular or semielliptical, concavo-convex, resupinate, the ventral valve concave and the dorsal valve convex. Ventral area striated, solid, with or without a central deltidial scar, or rarely a partial foramen, with similar features on the narrow area of the dorsal valve; inner margins of the cardinal areas of each valve crenulate, and from beneath the center of the ventral area there is often a strong process (frequently bilobed) which extends beyond the cardinal line. Muscular area of the ventral valve strongly

marked, and limited by a prominent border. Dorsal valve with a narrow hinge-area transversely or longitudinally striate or both, and marked in the center by a deltidial scar. Cardinal process double, each division notched or bidentate at the extremity; muscular area quadrangular, occupying a more or less elevated callosity, and a central carina rising from the lower part of this area is sometimes produced into a spiniform process in the center of the cavity."—HALL, Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., pp. 153, 154.

Type, *Strophodonta semifasciata*, Hall.* Niagara group.

OBSERVATIONS. The shells included in this genus are essentially Stropheodontas with the relative convexity of the valves reversed. It is evident from a careful inspection of any well-preserved example of STROPHONELLA, as already shown from a study of very young individuals of *S. striata*, Hall, that in early stages of growth the convexity of the valves is normal, reversion of convexity obtaining with growth.†

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* Since this is the first-named species in the list it will probably be regarded by students as the "type" of the genus, while in fact the generic description had reference to the better known Lower Helderberg forms, and this name was written first in a list of species given in their geological sequence, and including in addition to *S. semifasciata*, *S. Leavenworthana*, *S. cavumbona* and *S. punctulifera* (the last two probably identical), of the Lower Helderberg group, *S. ampla*, of the Upper Helderberg group, *S. reversa*, and *S. cœlata*, of the Chemung group; the interior characters of *S. semifasciata* were less known than in any of the others, and it was included in the group from its resupinate form and the character of the cardinal area, deltidium, etc. In *S. semifasciata*, as in the earlier forms of other generic types, the distinctive generic features may not be, and usually are not, as fully developed as they become in species of later geological periods.

† BEECHER and CLARKE. Development of some Silurian Brachiopoda, p. 25. Mr. FOERSTE has shown that the same conditions prevail in *S. patenta*, as in *S. striata* of the Clinton group of Ohio and other localities, and writes as follows:

"This shell begins its existence with the ventral valve convex and the dorsal concave. Later the anterior and lateral margins of the ventral valve become concave or turned up, and that of the dorsal valve convex or turned down. Since this is likewise true of *Strophodonta striata*, and only the exterior of these specimens is found, as a rule, these species would be difficult to distinguish, were it not for the fact that neither the convexity of the ventral valve, nor the point of strongest concavity of the dorsal valve, lies ever so near to the cardinal line in *S. patenta* as in *S. striata*. In other words, *S. patenta* remained for a longer time a shell of simple curvature."—Notes on Clinton Group Fossils, with special reference to Collections from Indiana, Tennessee and Georgia, by AUG. F. FOERSTE. Proceedings of the Boston Society of Natural History, vol. xxiv, pp. 300, 301. 1889.

See, also, *Strophomena patenta*; Geological Survey of Ohio; Palæontology, vol. ii, p. 115. 1875.

Whether this species is a STROPHOMENA or a STROPHONELLA remains to be determined, as we do not yet know the exact character of the hinge. The best specimens obtainable do not furnish conclusive evidence of crenulations along this line, while they do show a broad open delthyrium, with evidence of a small apical callosity, or deltidium. Should this species prove a STROPHOMENA, it is the last of its race, remarkable in having reverted to a primitive or orthoid condition of deltidial structure. Nevertheless the facts above given are certainly of very great interest as showing the progressive generic development in certain forms of Brachiopoda, and in this case suggests the inquiry as to how far certain strophomenoid characters may have been carried forward into STROPHONELLA.

In STROPHONELLA as in STROPHEODONTA, the earlier representatives possess some of the generic characters in an incipient condition. Species are not known to occur in faunas earlier than the Clinton, where this group is represented by (?) *S. patenta* and *S. striata*. The latter species is continued into the Niagara group, where it is associated with *S. semifasciata*, at Waldron, Indiana. The genus is represented in Europe by *S. euglypha* and *S. funiculata*.

Strophonella striata, Hall, of the Niagara fauna, has a deltidium highly developed in the immature stages of the shell, a prominent deltidial callus, and a short row of cardinal denticulations; it is, in fact, in these respects a reversed BRACHYPRION, bearing precisely the same relation to STROPHONELLA in its fuller development as that group does to STROPHEODONTA. The species also presents some differences from the later Strophonellas in its internal characters. In the pedicle-valve the muscular area is not enclosed, but its lateral margins are bounded by two curved ridges continued from the dental plates. In the brachial valve there is a similar arrangement produced by the continuation of the crural plates, but the muscular impressions are extremely faint, the radial markings of the surface extending quite to the base of the cardinal process.

Should it be considered useful to recognize the incipient and progressive features of the species *S. striata*, and probably *S. patenta*, towards a full manifestation of generic characters, and distinguish them from STROPHONELLA in its more mature condition of development, the term AMPHISTROPHIA may prove expressive of their apparent double relation as shown in the young and mature shells.

In the other Silurian species of STROPHONELLA the deltidium is more or less prominently developed as a convex plate, but in the Devonian these parts assume the character they possess in *Stropheodonta demissa*. In the species of the Lower Helderberg and Devonian the muscular area of the pedicle-valve is deeply impressed and strongly elevated at the margins, less like that of *Stropheodonta demissa* than that of the later Stropheodontas. In the Lower Helderberg fauna are the species *S. Headleyana*, Hall, *S. cavumbona*, Hall, *S. punctulifera*, Conrad, *S. Leavenworthana*, Hall, which possess all the typical features of the genus. It is probable that *Strophomena radiata* and *S. Conradi*, Hall, belong to the same genus, but their interior characters are not fully known. In the Upper Helderberg we

have the single species *S. ampla*, Hall; in the Hamilton group the genus is not represented, but reappears in the early Chemung faunas in *S. cælata*, *S. reversa* and *S. hybrida*, Hall, the last two occurring both in New York and Iowa.

Genus LEPTELLA, gen. nov.

PLATE XVA, FIGS. 12-16.

1862. *Leptæna*, Billings. Palæozoic Fossils, vol. i, pp. 73, 74, figs. 66, *a*, *b*, 67, *a*, *b*, *c*, p. 219.
1863. *Leptæna*, Billings. Geology of Canada, p. 231, figs. 242, 243.

By the courtesy of Mr. J. F. Whiteaves, an opportunity has been afforded of studying the original specimens of the species described by Mr. Billings as *Leptæna sordida*, from Limestone No. 2, at Point Lévis. These are in a silicified condition and show very clearly all the essential features of their structure. Though they are small, concavo-convex shells with an external aspect like that of Leptæna or Plectambonites, the character of the interior is such as to preclude the admission of the species into any of the generic divisions now recognized. A new name is therefore proposed for them.

Diagnosis. Shells small, normally concavo-convex. Outline semicircular or semielliptical. Hinge-line straight, making the greatest diameter of the shell. Pedicle-valve evenly convex, cardinal area moderately high, delthyrium for most of its extent, covered by a convex plate; teeth inconspicuous and unsupported by lamellæ; muscular impressions undetermined. Brachial valve slightly concave; cardinal area comparatively high; the delthyrium filled by the cardinal process, which, as viewed from behind, is divided by a median groove for its entire height. On the cardinal margin this process is double but less conspicuous than the crural plates, which are arched, and highly elevated above the hinge-line. They are short, terminate abruptly, and enclose deep sockets. The visceral area is flattened or concave, its anterior margin forming a double curve, from which line the surface of the valve is abruptly deflected. This visceral area is divided by a broad median ridge and its surface covered with fine, sharp radiating lines which end at the line of deflection.

Type, *Leptæna sordida*, Billings. Quebec group.

The structure of the articulating apparatus is the essential basis of distinction between this fossil and PLECTAMBONITES, but there is also no trace of the characteristic muscular scars of the latter genus. There can be little doubt that the species *Leptæna decipiens*, Billings, from the same formation and locality, belongs to the genus LEPTELLA. Without having had access to the original specimens, the figure given by Mr. BILLINGS of the interior of a brachial valve,* showing the double, erect cardinal process, the strong crural plates and the concave visceral area, seems sufficient to determine this point. Precisely similar features are shown in DAVIDSON's figures of his species *Leptæna Llandeiloensis*,† from the Upper Llandeilo of Ayrshire, and it may also be included in this genus.

The name LEPTÆNULOPSIS was proposed by HAUPT, in 1878,‡ but as the work in which it was described has not been accessible, no opinion can be expressed in regard to its value. The term has been used by JAEKEL,§ who refers to the species *Leptænulopsis simplex*, Haupt, certain small, smooth, semicircular, slightly convex shells, of the age of the Wenlock shale. This author also observes that HAUPT included in this genus a few shells having the general aspect of *Chonetes minima*, Sowerby; but this, according to DAVIDSON, is a strongly plicated shell, though without evidence of cardinal spines.

* Palæozoic Fossils, vol. i, p. 73, fig. 67 *c*.

† See Supplement to British Silurian Brachiopoda, p. 171, pl. xii, figs. 26–29. 1883.

‡ Die Fauna des Graptolithen-Gesteines; Ein Beitrag zur Kenntniss der silurischen Sedimentär Geschiebe der norddeutschen Ebene, von Karl Haupt. Band liv des Neuen Lausitzischen Magazins, Görlitz, 1878, p. 31.

§ Ueber das Alter des sogen. Graptolithen-Gesteines mit besonderer Berücksichtigung der in denselben enthaltenen Graptolithen: Zeitschrift der deutschen geologischen Gesellschaft, vol. xli, p. 695. 1890.

GENUS PLECTAMBONITES, PANDER. 1830.

PLATE XV, FIGS. 25–29, 32–36; AND PLATE XVA, FIGS. 34, 35.

1828. *Leptæna*, DALMAN. Kongl. Vetenskaps Acad. Handling., p. 109. pl. i. fig. 4 (not pp. 106–108).
1830. *Plectambonites*, PANDER. Beitr. zur Geognosie des russischen Reiches, p. 90, pl. iii, figs. 8, 16; pl. xxviii, fig. 19 (generic figures); pl. xix, fig. 1.
Leptæna, of DAVIDSON, 1853, 1871; ZITTEL, 1880: ŒHLERT, 1887, and authors generally.
1840. *Strophomena*, CONRAD. Ann. Rept. Geological Survey of N. Y., p. 211.
1842. *Strophomena*, EMMONS. Geology of N. Y.: Rept. Second District, p. 394, fig. 105.
1843. *Strophomena*, HALL. Geology of N. Y.: Rept. Fourth District, p. 104, fig. 4; p. 72, fig. 1.
1847. *Leptæna*, HALL. Palæontology N. Y., vol. i, p. 110, pl. xxxi B, fig. 2; p. 387, pl. lxxix, fig. 3.
1852. *Leptæna*, HALL. Palæontology of N. Y., vol. ii, p. 59, pl. xxi, fig. 1; p. 256, pl. liii, fig. 5.
1856. *Leptæna*, BILLINGS. Canadian Nat. and Geol., vol. i, p. 41, fig. 2; p. 138, pl. ii, figs. 14, 15.
1863. *Leptæna*, BILLINGS. Geology of Canada, p. 163, fig. 139.
1865. *Plectambonites*, SHALER. Bull. Mus. Comp. Zoology, No. 4, p. 64.
1873. *Leptæna*, MEEK. Geol. Survey of Ohio, vol. i. p. 70, pl. v, fig. 3.
1874. *Leptæna*, JAMES. Cincinnati Quarterly Journal of Science, vol. i, p. 151.
1875. *Leptæna*, MILLER. Cincinnati Quarterly Journal of Science, vol. ii, p. 57.
1879. *Leptæna*, ULRICH. Journal Cincinnati Soc. Nat. Hist., vol. i, p. 15, pl. vii, fig. 12.
1883. *Leptæna*, HALL. Ann. Rept. N. Y. State Geologist for 1882, pl. xv (46), figs. 25–29, 34–36.
1885. *Leptæna*, FOERSTE. Bull. Denison University, vol. i, p. 79, pl. xiii, fig. 5.
1887. *Plectambonites*, SHALER. Mem. Kentucky Geol. Surv., vol. i, pt. 2.

DIAGNOSIS. Shells usually small, normally concavo-convex. Surface covered with very fine striæ, often alternating in size. Hinge-line making the greatest width of the shell, the extremities often subauriculate. Cardinal area narrow in both valves, sometimes obscurely crenulated on the margins. Pedicle-valve with a moderately broad delthyrium which is partially closed by a convex plate, but mostly occupied by the cardinal process of the opposite valve. Apical foramen sometimes retained. Teeth prominent and supported by thickened plates, which are continued in broad outward curves for more than half the length of the valve, returning and uniting in the umbonal cavity, thus limiting two linguiform muscular scars, enclosing a more or less clearly defined adductor impression.

In the brachial valve, the dental sockets are deep, and often appear to transect the cardinal area. The cardinal process is simple and erect but by its coalescence with the short prominent crural plates, the posterior face appears trilobate. The crural plates end abruptly as in ORTHOTHETES; becoming thickened at about the middle of their length, giving origin to two low ridges or septa, which at first approach each other, and thence continue forward with a

slight divergence, thus forming the inner boundaries for two elongate muscular scars, which are less sharply defined on their outer margins. The muscular area is rendered quadripartite by two short transverse or oblique posterior furrows. Vascular impressions radial, sometimes digitate. Shell-substance fibrous, sparsely punctate.

Type, *Plectambonites planissima*, Pander. Lower Silurian of Russia.

OBSERVATIONS. In applying the term PLECTAMBONITES to the fossils usually referred to the genus LEPTÆNA, as interpreted by Mr. DAVIDSON in 1853, there is a sufficient justification in the necessities of the case, and in the rights of priority. In this work the example of many of the earlier writers has been followed, in applying the term LEPTÆNA to the type of structure expressed in DALMAN'S first and typical species, *L. rhomboidalis.*

If the progress of knowledge requires a stricter interpretation of generic values than was prevalent a generation ago, at least no injustice has been done to the

FIGS. 23, 24, 25. *Plectambonites planissima*. After PANDER.

founders of these groups. The first two of DALMAN'S four species of LEPTÆNA are synonymous with *L. rhomboidalis;* the third, *L. euglypha*, Hisinger, belongs to the genus STROPHONELLA, Hall; the fourth is *L. transversalis*, Wahlenberg, a well known and widely distributed representative of the genus PLECTAMBONITES, Pander, but which, under the conception of the genus, as rendered current by Mr. DAVIDSON, has served as the type of LEPTÆNA.

The genus PLECTAMBONITES was thus defined by its author:

"Die Rückenfläche ist wieder dreieckig, und würde man nach ihrer Gestalt allein sich richten, so müssten die hieher gehörigen Formen unmittelbar auf die Orthamboniten folgen, allein wir müssen zu gleicher Zeit die ganze Gestalt der Muscheln betrachten, und so sehen wir, dass diese, hauptsächlich durch die starke Concavität der Unterschale, näher an Productus kommen. Die Rückenfläche obgleich sie im Allgemeinen dreieckig, und anfangs ziemlich

horizontal ist, nimmt an Hohe allmählich ab und geht in eine Linie über, wie bei Productus; zu gleicher Zeit verändert sie ihre Richtung und indem sich der anfangs nach hinten hervorragende Hacken der Oberschale allmählich nach unten umschlägt, endlich ganz unter die Unterschale zu liegen kommt, hat die Rückenlinie eine im Verhältnisse zu den übrigen Terebratulen verkehrte Stellung angenommen, so dass die Berührung der beiden Schalen nach oben, der Hacken nach unten zu stehen kommt. Die Oberfläche der Plectamboniten ist glatt, mit flachen, dünnen, durch breite Zwischenräume von einander getrennte Längsstreifen versehen; der Hacken ragt sehr wenig hervor. Obere Schale mehr oder weniger, oft sehr stark convex, die untere sehr concav, und ahmt so sehr die Wölbung der oberen nach, dass zwischen beiden ein äusserst kleiner Zwischenraum übrig bleibt, ja dass man selbst verleitet werden könnte zu glauben, man habe nur eine einzige Schale vor sich."*

In this diagnosis given by PANDER the external characters of LEPTÆNA, Davidson (not Dalman), are very forcibly described, and although the internal features are not detailed, the generic figure, given on plate iii, figure 8, of the work cited, shows quite distinctly the peculiar cardinal process, crural plates and conspicuous muscular scars characteristic of the brachial valve of this group. PANDER described twelve species of PLECTAMBONITES, the first of which, *P. planissima*, must be taken as the type of the genus.

DE VERNEUIL, in 1845,† recognized these specific terms, combining many of them, though retaining several of the original names. Under *Leptæna convexa*, Pander, he included *P. planissima*, *P. crassa*, and *P. testudinata*, and remarks that he would have adopted the specific term *planissima* had it not been in use for a species of ORTHIS.†

* "The cardinal area [posterior surface] is again triangular, and judging from its outline alone, the forms belonging to this group must follow directly upon Orthambonites, but we must at the same time take into consideration the entire form of the shell, and thus we see that, mainly from the strong concavity of the lower valve, they approach more closely to Productus. The cardinal area, though in general triangular and at first nearly horizontal, gradually decreases in height and becomes linear, as in Productus; at the same time it changes its direction and the projecting beak of the upper valve, which at first is inclined backward, becomes gradually incurved and finally comes to lie wholly beneath the lower valve, so that the cardinal line has, in relation to the other Terebratulas, a reversed position, and hence the surface of contact of the valves is directed upward and the beak downward [see figure 40, page 234]. The surface of the Plectambonites is smooth with low, fine radiating lines separated by broad interspaces. The umbo is not very prominent. Upper valve more or less, often strongly convex, the lower very concave, and following so closely the curvature of the upper that between them is a space so extremely narrow as to easily lead to the deception that but a single valve is present."

† Géologie de la Russie et des Montagnes de l'Oural, pp. 228–232.

‡ "Cette coquille, que M. Eichwald à considérée comme nouvelle, nous paraît tellement identique avec le *Plectambonites planissima* de M. Pander, que nous n'aurions pas hésité a lui restituer ce nom, s'il n'avait

No author has been in a more favorable position for the study of PANDER's species than M. DE VERNEUIL, and his testimony is of much accessory importance in determining the real import of the genus PLECTAMBONITES. That he himself did not adopt the generic term, is due to the fact that he followed the prevailing custom of rendering to a genus the full breadth of meaning given to it by its author.

The elongate-lobate muscular scars, and the peculiar structure of the cardinal process are features which at once distinguish PLECTAMBONITES from allied genera. The former character is sometimes approached in certain species of RAFINESQUINA. Species of this genus have probably not appeared earlier than the faunas of the Trenton and Caradoc-Bala.*

The genus disappears in the Niagara; *P. transversalis* being the last survivor represented. It has been quite generally believed that the genus reappeared in the Trias and Jura, but many of these species have already proven to be of a distinct type of structure, and all of them will unquestionably be found to differ essentially from PLECTAMBONITES.†

GENUS CHRISTIANIA,‡ GEN. NOV.

PLATE XV, FIGS. 32, 33; AND PLATE XVA, FIG. 36.

1837. *Plectambonites*, PANDER. Beitr. zur Geognosie d. russ. Reiches. p. 92. pl. xix. figs. 9, 10.
1840. *Orthis*, VON EICHWALD. Ueber das Silur. Schicht. Syst. in Estland, p. 148.
1845. *Leptæna*, DE VERNEUIL. Géol. de la Russ. et des Mont. de l'Oural, p. 228, pl. xv, fig. 2.
1846. *Productus*, McCOY. Synopsis Silurian Fossils of Ireland, p. 25, pl. iii, fig. 4.
1853. *Leptæna*, DAVIDSON. Introd. British Fossil Brachiopoda, pl. viii, figs. 184, 185.
1871. *Leptæna*, DAVIDSON. British Silurian Brachiopoda, p. 326, pl. xlvii, figs. 7–18.
1883. *Leptæna*, DAVIDSON. British Silurian Brachiopoda, Suppl., p. 168, pl. xii, figs. 17–21.
1883. *Leptæna*, HALL. Rept. N. Y. State Geologist for 1882, Expl. pl. xv (46), figs. 32, 33.

DIAGNOSIS. Shells usually longitudinally elongated, sometimes semielliptical in outline; normally concavo-convex. Surface smooth or covered with fine radiat-

été appliqué par M. Eichwald à une *Orthis* de l'Esthonie. Parmi les Plectambonites de M. Pander, il y en a quatre qui ont une extrême ressemblence aux l'espèce dont nous nous occupons. Les *Plectambonites planissima* et *crassa* sont ceux que nous aurions voulu choisir comme types, mais ces deux noms ayant déjà été donnés à des *Orthis* ou à des *Atrypa*, nous préférons adopter le nom de *convexa* qui n'a pas encore été employé."

* The species *Leptæna sordida* and *L. decipiens*, described by Mr. BILLINGS, from the Lévis formation, prove to be generically distinct, and are discussed under the genus LEPTELLA.

† See the more recent determinations by MUNIER DE CHALMAS, BITTNER, ZUGMAYER, and others. The first of these authors has established the genera KONINCKELLA (type, *Leptæna liasina*, Bouchard) and CADOMELLA (type, *Leptæna Moorei*, Davidson), for some of the Liassic species.

‡ This name is proposed as an expression of regard for the memory of Dr. CHRISTIAN HEINRICH PANDER.

ing lines which are crossed by stronger, rather regular concentric plications. In the pedicle-valve the cardinal area is moderately high and the delthyrium in its normal condition probably closed by a convex plate. The teeth are very divergent and from their bases extend the elevated margins of two linguiform muscular scars, traversing the shell for almost its entire length. These scars, which may be regarded as the diductors, enclose two, much shorter, but still elongate adductors. In the brachial valve the cardinal process is bipartite on its anterior face, each of the lobes being grooved behind; the crural plates are very long and divergent, terminating in elevated extremities or crura. The lower moiety of these plates is produced on each side of a strongly elevated muscular ridge, curving slightly inward on the sides, then outward on approaching the anterior margin of the valve, each branch recurving and passing backward, parallel to the median axis, as far as the base of the cardinal process. The symmetrical spaces thus limited are each divided transversely at about one-third their length from the hinge-line, by a somewhat lower vertical ridge. The four areas thus enclosed represent the posterior and anterior scars of the adductor muscles. Between the inner muscular walls, in the median line, is a low, rounded, longitudinal ridge.

Type, *Leptæna subquadrata*, Hall. Lower Helderberg group.

Under the foregoing diagnosis it is proposed to include a few peculiar species which have usually been referred to Leptæna, of the type of *L. transversalis* (= Plectambonites). While they resemble in many features the structure of this group, there are important differences; in the composition of the cardinal process; in the arrangement of the muscular scars, and in the surface ornamentation. The most striking of these peculiarities are the great muscular scars bounded by high walls. In the pedicle-valve the outer diductor scars are much more elongated than ever in Plectambonites, and in the brachial valve the adductors have the quadruplicate arrangement usually seen to the best advantage in species of Orthis. In *Plectambonites transversalis*, however, these adductor impressions, though greatly elongated, are nearly parallel to each other, all converging toward, or meeting in the umbonal region.

There are at least three well known species which are clearly referable to this proposed genus: *Leptæna subquadrata*, Hall,* from Perry county, Tennessee, referred to the age of the Lower Helderberg group; *Leptæna tenuicincta*, McCoy, elaborately described by Mr. DAVIDSON,† from the Upper Llandeilo and the Caradoc series; *Plectambonites ovata* and *P. oblonga*, Pander, which are united by DE VERNEUIL‡ under the term *Leptæna oblonga*, from the Lower Silurian beds in the vicinity of St. Petersburg. DAVIDSON includes in *L. tenuicincta* the *Leptæna ænigma* of DE VERNEUIL,§ from the Lower Silurian beds of the Island of Gotland, a shell much less elongated than the typical *L. tenuicincta*, and whose interior has not been described.

GENUS LEPTÆNISCA, BEECHER. 1890.

PLATE XV, FIGS. 30, 31; AND PLATE XVA, FIGS. 19–30.

1859. *Leptæna*, HALL. Palæontology of N. Y., vol. iii, p. 197, pl. xviii, fig. 2.
1883. *Leptæna?* (sub-genus?), HALL. Rept. N.Y. State Geologist for 1882; Expl. pl. xv (46), figs. 30, 31.
1890. *Leptænisca*, BEECHER. American Journal of Science, vol. xl, p. 238, pl. ix, figs. 1–9.

DIAGNOSIS. "Shell concavo-convex, attached to foreign objects by calcareous cementation of the ventral beak. Valves articulated by the teeth and sockets. Dorsal or socket valve concave; interior with a broad, more or less defined, spiral impression on each side of the median line, making a single volution. Adductor impressions small. Cardinal line [area] narrow, bearing in the center two prominent, bilobed, cardinal processes, separated to admit the vertical septum in the opposite beak. Ventral valve convex, area elongate-triangular, fissure covered with a pedicle-sheath. Cardinal muscular scar supported on, or limited by a vertical septum, on each side of which, in the anterior half, is a small adductor scar. Shell-structure punctate.

"Type, *Leptæna concava*, Hall."* Lower Helderberg group.

This interesting genus includes a few species of attached shells having the general form and contour of PLECTAMBONITES, but with a peculiar combination

* This species is first mentioned and illustrated in the Report of the N. Y. State Geologist for 1882, explanation of plate xv (46), figs. 32, 33. 1883.

† British Silurian Brachiopoda, pp. 326–328, pl. xlvii, figs. 7–18.

‡ Géologie de la Russie, etc., p. 228, pl. xv, fig. 2.

§ Bulletin de la Société Géologique de France, 2e Sér., vol. v, p. 340, pl. iv, fig. 6. 1848.

BEECHER. "On LEPTÆNISCA, a new genus of Brachiopod from the Lower Helderberg group" (*op. cit.*)

of internal characters, the most striking of which are, the strong dental lamellæ, prolonged into the interior of the valve as vertical walls, forming the lateral boundary of the muscular impression; the cardinal process, quadrifid on its posterior and bifid on its anterior face; the very large, broad, much elongated spiral brachial ridges, which make something more than a single convolution.

It is observed by Mr. BEECHER that these spiral ridges are better comparable to the so-called reniform impressions of the productids than to the brachial supports and ridges in KONINCKINA and DAVIDSONIA. Elsewhere will be found quoted the opinion of the late Professor NEUMAYR, that the reniform impressions in CHONETES, PRODUCTUS, etc., were produced by the coiled arms of the animal. The presence of a cardinal process like that in CHONETES and PRODUCTELLA seems to sustain the view of the closer relations of LEPTÆNISCA to this rather than any other group of the articulate brachiopoda. In regard to the degree of attachment of the pedicle-valve, two additional species, from the same formation, afford some interesting facts. *Leptænisca concava* has the cicatrix restricted to a very narrow area about the umbo; *L. tangens*, a smaller species, is usually found adhering to branches and fronds of bryozoa, and the scar is often deep and may cover the umbonal area; while *L. adnascens* is attached by the entire external surface of the pedicle-valve, generally to shells of other brachiopods, preferably to ORTHIS. A young individual of the last species retains the brachial valve, and shows a well defined cardinal area and a prominent arched deltidium.

GENUS DAVIDSONIA, BOUCHARD 1849.

PLATE XVA, FIGS. 31–33.

1845. *Leptæna?*, DE VERNEUIL. Géol. Russie et des Mont. de l'Oural, p. 227, pl. xv, fig. 9.
1849. *Davidsonia*, BOUCHARD. Annals des Sciences Naturelles. 3d Ser., vol. xii, p. 92, pl. i, fig. 2.
1852. *Davidsonia*, DE KONINCK. Mem. de la Société Royale de Liège, vol. viii, p. 149, pl. i, figs. 1–4; pl. ii, fig. 1.
1853. *Davidsonia*, DAVIDSON. Introd. British Fossil Brachiopoda, p. 110, pl. viii, figs. 186–193.
1853. *Davidsonia*, SCHNUR. Palæontographica, vol. iii, p. 219, pl. xxxix, fig. 4.
1855. *Davidsonia*, DE KONINCK. Mem. de la Société Royale de Liège, vol. x, p. 281.
1858. *Davidsonia*, DAVIDSON. The Geologist. No. xi, pl. xii, figs. 33, 34.
1865. *Davidsonia*, DAVIDSON. British Devonian Brachiopoda, p. 74, pl. xi, figs. 13–16; pl. xv, fig. 18.
1871. *Davidsonia*, QUENSTEDT. Petrefactenk. Deutschlands, Brachiopoden, p. 689, pl. lxi, figs. 103–109.
1871. *Davidsonia*, KAYSER. Zeitschr. der deutsch. geolog. Gesellsch., vol. xxiii, p. 632, pl. xii, fig. 9.

DIAGNOSIS. Shell thick, plano-convex, transversely oval. Surface smooth or with concentric growth-lines, fixed to foreign bodies by the umbonal portion and the greater part of the surface of the pedicle-valve. Hinge-line straight and quite narrow. On the pedicle-valve the delthyrium is covered by a convex imperforate plate; the teeth are large, the dental lamellæ obscure. The muscular area is comparatively small, lying in the umbonal region, and is subdivided into two cardinal scars enclosing an elongate adductor. In the pallial region there is a low median septum which separates two conical callosities of the shell, having their apices directed toward the opposite valve. These protuberances are grooved by a spiral furrow which makes five or six volutions, and are frequently crossed by vascular sinuses.

In the brachial valve the deltidial covering is convex, embracing the base of the posterior face of the cardinal apophysis. The cardinal process has very much the same structure as in PLECTAMBONITES, consisting of a central, short, erect process, to which the crural plates are attached, giving it a trilobate appearance. These plates terminate abruptly at their distal extremities. The muscular area is quadruplicate and of about the same size as in the opposite valve. Two conical depressions in the pallial region correspond to the protuberances of the opposite valve. Shell-substance punctate (?).

Type, *Davidsonia Verneuili*, Bouchard. Middle Devonian.

OBSERVATIONS. In 1859, DE KONINCK detected the existence of calcified spiral brachial supports in this genus, which would give it somewhat the character of ATRYPA. Dr. ŒHLERT has placed the genus with some doubt in the family *KONINCKINIDÆ*, with KONINCKINA, ANOPLOTHECA, KONINCKELLA, AMPHICLINA, THECOSPIRA; the last of these genera being similarly attached by the surface of the pedicle-valve, and all of them being spirigerous.

DAVIDSONIA occurs in the middle Devonian (Crinoiden-schichten) of the Eifel, and at an essentially equivalent horizon in England, Belgium and Russia. But two species have been described, *D. Verneuili*, Bouchard, and *D. Bouchardiana*, de Koninck, the latter being regarded by F. ROEMER and KAYSER as identical with the former. The genus is not represented in American faunas, so far as known.

GENUS CHONETES, FISCHER DE WALDHEIM. 1837.

PLATE XVA, FIGS. 11-13; AND PLATE XVI, FIGS. 1-11, 14, 15, 18-27, 32-36, 39, 41, 43, 44.

1793. *Pecten.* URE. History of Rutherglen and East Kilbride, p. 317, pl. xvi, figs. 10, 11.
1820. *Hysterolithes, Terebratulites,* SCHLOTHEIM. Die Petrefacktenkunde auf ihr. jetz. Standpunkt.
1828. *Leptæna,* VON BUCH. Abhandl. Akad. Wissensch. zu Berlin, pp. 53, 70, pl. iii.
1828. *Orthis,* DALMAN. Kongl. Vetenskaps Akad. Handlingar, p. 111, pl. i, fig. 5.
1834. *Orthis, Leptæna,* KLÖDEN. Verstein. Mark Brandenburg, pp. 179, 181.
1836. *Orthis, Leptæna,* GOLDFUSS, VON BUCH. Abhandl. d. Königl. Akad. d. Wissensch. zu Berlin.
1836. *Spirifera,* PHILLIPS. Geology of Yorkshire, vol. ii, pl. ii, fig. 6.
1837. *Chonetes,* FISCHER DE WALDHEIM. Oryctographie du Gouv. de Moscou, pt. ii, p. 134, pl. xxvi, figs. 8, 9.
1837. *Orthis,* HISINGER. Lethæa Suecica, p. 70, pl. xx, fig. 7.
1839. *Strophomena,* CONRAD. Second Ann. Rept. Palæont. Dept. N. Y., p. 64.
1841. *Orthis, Leptæna,* PHILLIPS. Palæozoic Fossils Cornwall, Devon and West Somerset, p. 138, pl. lx, fig. 104.
1841. *Orthis,* D'ARCHIAC and DE VERNEUIL. Descr. Foss. Rhenish Provinces, p. 397.
1841. *Productus,* VON BUCH. Abhandl. d. Königl. Akad. d. Wissensch. zu Berlin, p. 25.
1842. *Strophomena,* CONRAD. Journ. Acad. Nat. Sci. Phila., vol. viii, pp. 253, 257, pl. xiv, figs. 1, 13.
1842. *Strophomena,* VANUXEM. Geology of N. Y.; Rept. Third District, p. 149.
1842. *Leptæna, Productus,* D'ORBIGNY. Voyage dans l'Amérique Méridionale, Paléontologie, p. 49, pl. iv, figs. 10, 11.
1843. *Leptæna,* DE CASTELNAU. Essai sur le Système Silurien de l'Amérique septentrionale, p. 39, pl. xiv, fig. 9.
1843. *Strophomena,* HALL. Geology of N. Y.; Rept. Fourth District, pp. 73, 171, 175, 180, 222.
1844. *Leptæna.* MCCOY. Synopsis Carb. Fossils Ireland, p. 27.
1844. *Delthyris,* FAHRENKOHL. Bemerk. über einige Foss. d. Moskow und Kaluga Gouv.
1845. *Chonetes,* DE VERNEUIL. Géologie de la Russie et des Mont. de l'Oural, p. 242.
1846. *Chonetes,* MORRIS and SHARPE. Quarterly Journal Geological Society London, vol. ii, p. 274, pl. x, fig. 14.
1847. *Chonetes,* DE KONINCK. Recherches sur les Animaux Fossiles, pp. 192, 200, 204, 206, 215.
1852. *Chonetes,* HALL. Stansbury's Expl. Great Salt Lake, p. 410, pl. iii, fig. 1.
1852. *Chonetes,* HALL. Palæontology of N. Y., vol. ii, p. 64, pl. xxi, fig. 10.
1852. *Chonetes,* OWEN. Rept. Geol. Survey Iowa, Wisconsin and Minnesota, p. 583, tab. v, fig. 12.
1854. *Chonetes,* DAVIDSON. Introd. British Fossil Brachiopoda, p. 113.
1854. *Chonetes,* NORWOOD and PRATTEN. Journ. Acad. Nat. Sci., Philadelphia, vol. iii, pp. 24-30, pl. ii, figs. 2, 4-12.
1855. *Chonetes,* SHUMARD. Geology of Missouri, pp. 201, 202, 216, pl. c, fig. 1.
1855. *Leptæna,* MCCOY. British Palæozoic Fossils, p. 454.
1857. *Chonetes,* HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 116, 119, 145-150
1857. *Chonetes,* SHUMARD. Engelmann's Rept. Bryan's Expl. from Ft. Leavenworth to Bryan's Pass.
1858. *Chonetes,* STEVENS. American Journal of Science, vol. xxv, p. 263.
1858. *Chonetes,* MEEK and HAYDEN. Proc. Academy of Natural Sciences, Phila., vol. x, p. 262.
1858. *Chonetes,* HALL. Rept. Geol. Survey of Iowa, vol. i, pt. ii, p. 598, pl. xii, figs. 1, 2.
1859. *Chonetes,* SHUMARD. Trans. St. Louis Acad. Science, vol. i, p. 390.
1860. *Chonetes,* WORTHEN. Trans. St. Louis Acad. Science, vol. i, p. 571.
1860. *Chonetes,* HALL. Canadian Naturalist and Geologist, vol. v, pp. 144, 145.
1860. *Chonetes,* MEEK and WORTHEN. Proc. Academy of Nat. Sciences, Phila., p. 450.
1861. *Chonetes,* NEWBERRY. Ives' Rept. Colorado River of the West, p. 128.
1861. *Chonetes,* BILLINGS. Canadian Journal Science and Arts, vol. vi, p. 349.

1861. *Chonetes*, DAVIDSON. British Carboniferous Brachiopoda, pp. 182–191, pl. xlvi, figs. 3–7; pl. xlvii, figs. 1–7, 12–18, 25, 28.
1862. *Chonetes*, A. WINCHELL. Proc. Acad. Nat. Sci. Phila., vol. xiv, pp. 410, 411.
1862. *Chonetes*, WHITE. Proc. Boston Society Natural History, vol. ix, p. 29.
1863. *Chonetes*, A. WINCHELL. Proc. Acad. Nat. Sci., Phila., vol. xv, p. 5.
1863. *Chonetes*, BILLINGS. Geology of Canada, p. 368.
1864. *Chonetes*, MEEK and HAYDEN. Palæontology of Upper Missouri, p. 22, pl. i, fig. 5.
1865. *Chonetes*, DAVIDSON. British Devonian Brachiopoda, pp. 94–96, pl. xix, figs. 4–12.
1865. *Chonetes*, A. WINCHELL. Proc. Academy of Natural Sciences Phila., p. 116.
1866. *Chonetes*, A. WINCHELL. Geological Rept. Lower Peninsula Michigan, p. 92.
1866. *Chonetes*, GEINITZ. Carbon und Dyas, pp. 58, 60, pl. iv, figs. 12–18.
1866. *Chonetes*, MEEK and WORTHEN. Geological Survey of Illinois, vol. ii, p. 253, pl. xviii, fig. 8.
1867. *Chonetes*, HALL. Palæontology of N. Y., vol. iv, pp. 115–145, pl. xx, figs. 1–7; pl. xxi, figs. 1–13; pl. xxii, figs. 1–28, 44.
1867. *Chonetes*, HALL. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 242.
1868. *Chonetes*, MEEK and WORTHEN. Geological Survey of Illinois, vol. iii, p. 505, pl. xv, fig. 8.
1868. *Chonetes*, MEEK. Trans. Chicago Acad. Sciences, vol. i, p. 93, pl. xiii, fig. 2.
1870. *Chonetes*, A. WINCHELL. Proc. Amer. Philosophical Society, vol. xii, p. 250.
1870. *Chonetes*, MEEK and WORTHEN. Proc. Acad. Nat. Sci. Phila., p. 35.
1871. *Chonetes*, DAVIDSON. British Silurian Brachiopoda, pp. 331–335, pl. xlix, figs. 13–26.
1872. *Chonetes*, MEEK. Final Rept. Palæont. Eastern Nebraska, pp. 170, 171, pl. i, fig. 10; pl. iv, figs. 9, 10; pl. vi, fig. 10; pl. viii, figs. 7, 8.
1873. *Chonetes*, MEEK and WORTHEN. Geol. Survey of Illinois, vol. v, p. 570, pl. xxv, fig. 11.
1873. *Chonetes*, NICHOLSON. Palæontology Province of Ontario, pp. 74, 75.
1874. *Chonetes*, RATHBUN. Bull. Buffalo Soc. Nat. Hist., vol. i, pp. 250–253.
1874. *Chonetes*, DERBY. Bulletin Cornell University, vol. i, pp. 41, 43, pl. vi, figs. 3, 12, 19; pl. viii, figs. 11, 14, 15, 19; pl. ix, figs. 8, 9.
1874. *Chonetes*, BILLINGS. Palæozoic Fossils, vol. ii, pp. 15–29.
1874. *Chonetes*, WHITE. Prelim. Rept. Wheeler's Surv. west 100th Merid., p. 19.
1875. *Chonetes*, WHITE. Geogr. and Geol. Surv. west 100th Merid., pp. 121–123, pl. ix, figs 6–8.
1876. *Chonetes*, MEEK. Stimpson's Survey Great Basin of Utah, p. 348.
1876. *Chonetes*, HALL. Document Ed. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., pl. xxii, fig. 15.
1877. *Chonetes*, HALL and WHITFIELD. U. S. Geological Expl. Fortieth Parallel, p. 253, pl. iv, fig. 9.
1878. *Chonetes*, DAWSON. Acadian Geology, Third Edition, pp. 595, 596.
1879. *Chonetes*, HALL. Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., p. 155, pl. xxii, figs. 11–15.
1879. *Chonetes*, EMERSON. Geology of Frobisher Bay; Nourse's Narr. Hall's Arctic Expedition.
1879. *Chonetes*, RATHBUN. Proc. Boston Society Natural History, vol. xx, pp. 18–21.
1882. *Chonetes*, HALL. Eleventh Ann. Rept. State Geologist Indiana, p. 293, pl. xxii, figs. 11–15.
1882. *Chonetes*, WHITFIELD. Geology of Wisconsin, vol. iv, p. 327, pl. xxv, fig. 16.
1882. *Chonetes*, DAVIDSON. British Devonian Brachiopoda, Supplement, pp. 54, 55, pl. iii, figs. 23, 24.
1883. *Chonetes*, HALL. Rept. N. Y. State Geologist for 1882, plate xvi (47).
1884. *Chonetes*, HALL. Thirty-fifth Rept. N. Y. State Mus. Nat. Hist., pl. xxii, fig. 8.
1884. *Chonetes*, WAAGEN. Salt-Range Fossils; Brachiopoda, pp. 614–640, pls. lviii–lxi.
1884. *Chonetes*, WALCOTT. Palæontology Eureka Dist., pp. 123–127, pl. ii, figs. 8, 13; pl. xiii, figs. 14, 15.
1884. *Chonetes*, WHITE. Thirteenth Ann. Rept. State Geologist Indiana, p. 128, pl. xxv, figs. 7, 8.
1885. *Chonetes*, CLARKE. Bull. No. 16, U. S. Geological Survey, p. 24.
1888. *Chonetes*, KEYES. Proc. Academy of Natural Sciences Phila. (Extract), pp. 7, 8, pl. xii, fig. 3.
1888. *Chonetes*, HERRICK. Bull. Denison University, vol. iii, pp. 35–37, pl. i, fig. 4; pl. ii, fig. 21; pl. iii, figs. 12, 14, 21; pl. vii, fig. 22; pl. xii, fig. 3.
1889. *Chonetes*, NETTELROTH. Kentucky Fossil Shells, pp. 66–68, pl. xvii, figs. 16–19; pl. xviii, figs. 18–20; pl. xxxi, figs. 20, 30.
1889. *Chonetes*, SIMPSON. Trans. American Philosophical Society, p. 438.

Diagnosis. Shells semicircular or transverse, usually normally concavo-convex, sometimes plano-convex. Hinge-line straight, making the greatest diameter of the shell. Pedicle-valve with a narrow concave or flat cardinal area; the delthyrium more or less completely covered by a convex imperforate deltidium. The upper margin of the area bears a single row of hollow vertical or divergent spines, which increase in length toward the cardinal angles; these spines are the prolongations of tubes which penetrate obliquely the substance of the shell in the cardinal region, converging toward the apex of the valve till they reach the surface, where they turn at an abrupt angle upward and outward and are thence continued as hollow spines. Cardinal teeth strong. A low median ridge, slightly thickened at its posterior extremity, where it is sometimes coalesced with the deltidium, extends forward, dividing the muscular region. The muscular scars are usually faint, and consist of flabelliform diductors which partially enclose elongate median adductors.

In the brachial valve the cardinal area is very narrow, and without spines The deltidium is partially developed, resting against the cardinal apophysis This process is very similar in character to that in Plectambonites, consisting of a median portion, coalescing at its base with the elongate crural plates. On its posterior face it is divided by a narrow median furrow and two broader lateral grooves, giving it a quadrilobate appearance. The crural plates are slightly divergent from the hinge-line, bounding narrow, elongate sockets. A median ridge separates the quadruplicate muscular impression, and from between the anterior and posterior members of this impression originate two linear brachial ridges, which extend outward, recurving toward the median line at about the middle of the valve, making a reniform curve. Interior surface of both valves strongly papillose in the pallial region.

External surface usually covered with radiating striæ, rarely smooth or concentrically rugose. Shell-substance fibrous-punctate.

Type, *Orthis striatella*, Dalman. Upper Silurian.

Observations. Chonetes is remarkable for the persistence of its characters. From its appearance in the middle Silurian to its disappearance in the Permian, this type of structure has been maintained with few essential modifications. On

account of this stability in its features it is difficult to establish any satisfactory subdivision of its members, especially since the genus has been left more compact by the recent elimination of some of its aberrant forms DE KONINCK proposed* a classification of the species into five sections, based upon the nature of the external ornamentation, as follows:

I. *Concentricæ*, those with concentric folds or undulations, like *C. concentrica.*

II. *Comatæ*, those with more than one hundred smooth radiating striæ.

III. *Striatæ*, those in which the striæ are less than one hundred and more than thirty.

IV. *Plicosæ*, those with less than thirty striæ.

V. *Rugosæ*, those with rugose radiating plications.

An additional group was proposed by Mr. DAVIDSON, viz., *Læves*, to include smooth shells, like *C. polita*, McCoy, *C. glabra*, Geinitz, etc.; and WAAGEN has more recently added another, *Grandicostatæ*, for species with very strong and high radiating ribs. Such an arrangement as this is of course quite conventional, and can not meet the requirements of an exact classification, though it may still serve a useful purpose in the absence of a better one. Of the first of DE KONINCK'S sections, *Concentricæ*, we have no representation in American faunas. The second and third were properly united by WAAGEN, and will include the great majority of all known species; the *Plicosæ* may embrace such forms as *C. mucronata* and *C. lepida*, Hall; of the *Rugosæ* and *Grandicostatæ*, we have no representatives. The *Læves* are a group characterizing the Carboniferous and Permian, of which we have the species *C. glabra*, Geinitz,† while *C. polita*, McCoy, occurs in the Carboniferous throughout Great Britain, and WAAGEN has described‡ five additional species of this type from the Productus-limestone of India.

The genus CHONETES presents many points of structure in common with PLECTAMBONITES. This fact is best seen in the usual size and general contour

* Monographie des genres *Productus* et *Chonetes*. 1847.

† The species *C. glabra*, Geinitz, and *C. lævis*, Keyes, are synonymous; the former having precedence in time must stand, since the *C. glabra*, Hall, has been shown to be identical with *C. lineata*, Vanuxem; Pal. N. Y., vol. iv, p. 121.

‡ Salt-Range Fossils, vol. i, pl. iv, pp. 616, *et seq.* 1884.

of the shell, and in the cardinal area and articulating apophyses, and may be regarded as of some significance in determining the source and point of departure of the productoid stock. Œhlert has demonstrated the existence of reniform or hook-shaped brachial ridges in the genus Stropheodonta (*S. Leblanci*);* and although a feature of extremely rare occurrence in that group, it should be given full value in its bearing upon the same question. It has been remarked by many observers that in the earlier forms of Chonetes the reniform ridges are but faintly, if at all, manifest; the more distinctly productoid characters of the genus becoming pronounced only with the advent of Productus. † The peculiar cardinal tubes, which are continued into spines, sometimes of a length equal to that of the valves, constitute a feature found only in this group of shells, including Chonostrophia and Chonopectus, here described for the first time, Chonetina, Krotow, and Chonetella, Waagen. The existence of these passages across the ventral area, opening into the interior of the shell, was first observed by Keyserling,‡ and was discussed at length in Volume IV of the Palæontology of New York,§ and more recently by Mr. John Young, in Davidson's Appendix to his Supplement on the Brachiopoda.‖ Fine hair-like spines are sparingly scattered over the striæ in *C. papilionacea*, Phillips, of the Carboniferous limestone, and traces of similar processes have been mentioned by various writers for other species.¶

It is probably true in many cases that the supposed bases of the spines are but the coarse punctations of the inner laminæ of the shell-substance, exposed by the abrasion of the impunctate outer or epidermal layer. Furthermore, the *Chonetes papilionacea* is a species whose generic affinities are still debatable. The shell is of immense size, far exceeding that of any other form referred

* Annales des Sciences Géologiques, vol. xix, p. 63.

† Œhlert observes "que les modifications du genre Chonetes ont lieu tout particulièrement à l'époque carbonifère, et que leur tendance dans certaines espèces, à de rapprocher de la forme productoïde semble coïncider avec l'apparition et la développement maximum du genre Productus. Les Chonetes dévoniens, et surtout ceux qui appartiennent à l'époque silurienne, présentent des caractéres plus nettement définis et plus facilement reconnaissables."

‡ Geogn. Beobachtungen auf einer Reise in das Petschora-land, p. 213. 1846.

§ " " " " p. 117. "

‖ " " " " p. 281. "

¶ See Davidson, Carboniferous Brachiopoda, p. 188, pl. viii, fig. 8 b. 1872; Waagen, Salt-Range Fossils, genus Chonetes.

to the group, and this fact, taken in connection with its spinous striæ, leads to the presumption that the interior, when known, will show some generic variations of more or less importance.

The earliest appearance of CHONETES in American Palæozoic faunas, is in the Clinton group (*C. cornuta*, Hall); *Chonetes undulata*, *C. tenuistriata*, *C. Novascotica*, Hall, are known in the Niagara fauna. There is an undescribed species in the Lower Helderberg, and at least one other in the Oriskany sandstone of New York, but these are of rare occurrence. BILLINGS has described from the Lower Devonian (Oriskany horizon) of Gaspé and the Bay of Chaleurs, *C. Canadensis* and *C. Antiopia*. In the Devonian the species multiplied rapidly, and then attained their maximum development, both in number and size; becoming less conspicuous in the following faunas, as the productoids increased in development and importance.*

Whether the cardinal spines are ever absent in true CHONETES is not yet positively determined; they are often obscure, and as often lost from accidental causes, but no satisfactory evidence of their non-existence has been shown in any species that can be strictly referred to CHONETES; although WAAGEN believes that they were probably never developed in one of his species from the Salt-Range. An analogous structure is exhibited by the species *Leptæna? nucleata*, Hall,† a small, obscure shell, occurring in great abundance in certain outcrops of the Oriskany sandstone in New York and Illinois, and in the Upper Helderberg chert of Cayuga, Province of Ontario. In contour the shell is concavo-convex, and externally is unlike CHONETES in having a smooth surface with concentric squamose lines or lamellæ of growth, but no radiating striæ, and no spines, either on the cardinal margin or over the surface. The delthyrium appears to have been uncovered. On the interior the pedicle-valve has a broad, thick and considerably elevated median septum, which takes its origin at, or just in front of the apex and is continued over about one-third the length of the shell, ending quite abruptly. In well preserved internal casts the impressions of the

* WAAGEN observed (1884), when adding to the genus fourteen new species from the Productus limestone, that only about sixty species had been previously known, according to ZITTEL. This estimate is far too low, since just about sixty well defined species have been described from American faunas alone.

† Palæontology of New York, vol. iii, p. 419, pl. xciv, figs. 1 *a–d*.

teeth are moderately developed, and indicate considerable divergence in the dental ridges. A most remarkable feature on these casts, is the presence, on each side of the umbo, of a minute, greatly elongate and gently tapering cone, the base of which is joined to the cast at about two-thirds the distance from the apex to the cardinal angle; and from this point each one is inclined toward the apex of the shell, and terminates in a free extremity. These delicate cones which are so fragile that they are easily lost and rarely preserved, penetrate, but do not transect the cavity originally filled by the substance of the cardinal portion of the valves; they are evidently the casts of a single pair of large and very oblique spine-tubes, which were not continued into spines as in CHONETES, and evidently did not penetrate to the outer surface of the cardinal margin. The inner opening of these blind tubes is situated below and in front of the cardinal area, and their obliquity greatly exceeds that observed in the cardinal tubes of CHONETES. The muscular impressions consist of two flabellate diductors, between which lie two elongate, narrow adductors. Over the pallial region the surface is pustulose. In the brachial valve the cardinal process appears to be simply bilobate, the crural plates narrow and obscure. From the base of the cardinal process extend two slightly divergent median ridges which are considerably elevated at the center of the shell and terminate abruptly. These enclose an elongate muscular scar. There are also two lateral ridges curving outward and then inward, enclosing small thickened areas which appear to be of muscular origin, while the ridges themselves have the curvature of, and suggest the "reniform impressions." Nearly the entire inner surface of this valve is covered with radiating rows of strong pustules. This curious shell represents a phase of development in the chonetid type not hitherto described and it may be convenient to separate it under the sub-generic name ANOPLIA.* Illustrations of the only species known to possess these features, *Leptæna? nucleata*, will be found on Plate XVA, figures 17 and 18, and Plate XX, figures 14–17.

* MEEK and WORTHEN, in describing this species under the name *Leptæna? nucleata* (Palæontology of Illinois, vol. iii, p. 394; 1868), observed that "this curious little shell does not present the form or internal characters of LEPTÆNA, and will probably be found to be a new generic type."

Genus CHONETINA, Krotow. 1888.

1884. *Chonetella*, Krotow (not Waagen). Artinskische Etage, p. 274.
1888. *Chonetina*, Krotow. Mém. du Comite Géologique, vol. vi, p. 500.

A brief description of the characters of this genus* has been given by Œhlert,† from which it appears that "Chonetina differs from Chonetes by its very convex ventral valve, having a profound sinus; the small valve, very concave, follows the curvature of the larger; in the interior of the dorsal valve are tubercles arranged in radiating series which unite to form high, compact lamellæ, extending from the beak to the anterior margin; two of these, more prominent than the rest, limit the surface occupied by the sinus of the larger valve. The type, *C. artiensis*, Krotow, belongs to the horizon of the Artinskian grit (Permian)."

Without actual knowledge of the specimens upon which this separation from Chonetes has been based, it may be imprudent to express an opinion as to the value of the proposed genus. The American species which are deeply sinused on the pedicle-valve, *e.g.*, *Chonetes Verneuiliana* and *Ch. mesoloba*, Norwood and Pratten, show no valid grounds for separation from Chonetes.

Genus CHONOSTROPHIA, gen. nov.

Plate XV b, figs. 14-19; and Plate XVI, figs. 13, 29.

1857. *Chonetes*, Hall. Tenth Rept. N Y. State Cab. Nat. Hist., p. 56
1859. *Chonetes*, Hall. Palæontology of N. Y., vol. iii, p. 418, pl. xciii. figs. 1 *a–d*, 2 *c*.
1882. *Chonetes*, Whitfield. Annals N. Y. Academy of Science, vol. ii, p. 213.
1883. *Chonetes*, Hall Rept. N. Y. State Geologist for 1882, pl. xvi, figs. 13, 29.

Diagnosis. Shell reversed, concavo-convex, the pedicle-valve being slightly convex about the umbo, but becoming broadly concave over the pallial region. Outline and contour strophomenoid; valves extremely tenuous and compressed; surface covered with fine, alternating or fasciculate striæ. In the pedicle-valve the upper margin of the cardinal area bears a row of hollow spines of the same structure and arrangement as in Chonetes. The delthyrium is narrow and appears to be more or less completely closed. The teeth are quite strong and

* The original descriptions of both genus and species are in the Russian language.
† L'Annuaire géologique universel, vol. v, p. 1152. 1889.

rest upon the bottom of the valve; between them arises a low median septum which may be traced from one-third to one-half the length of the valve, dividing a subcordate muscular area, the outer margins of which are distinctly elevated.

In the brachial valve the crural plates are united to form a bilobed cardinal process. The outer face of this process has not been observed; on the inner surface it is not continued into a median septum but ends abruptly. Muscular area very faintly defined in the type-species. Internal surface over the pallial region finely papillose. Shell-substance fibrous, punctate.

Type, *Chonetes reversa*, Whitfield. Corniferous limestone.*

OBSERVATIONS. The peculiar species which is taken as the type of this new division occurs in the fauna of the Corniferous limestone, at Delaware, Ohio, and Cayuga, Province of Ontario. Certain of its peculiarities indicated will not permit its strict generic association with CHONETES, *e.g.*, the reversed convexity and surface ornamentation of the valves, and the apparent structure of the cardinal process. In a general sense the relation between CHONOSTROPHIA and CHONETES is the same as that between STROPHONELLA and STROPHEODONTA, STROPHOMENA and RAFINESQUINA; but, as in these cases, the reversal of the relative convexity of the valves is not the only difference of importance. *Chonetes complanata*, Hall, of the Oriskany sandstone, a much larger, more transverse form, also with reversed convexity and with more strongly developed flabelliform muscular areas, may be placed in the same division until its characters shall be more fully determined. In a different facies of the same fauna is another, as yet undescribed congeneric species; and Mr. BILLINGS has described* a form from an equivalent horizon at Gaspé, *Chonetes Dawsoni*. In the shaly limestone of the Lower Helderberg series, there occurs a species described in this volume as *Chonostrophia Helderbergia*, sp. nov.

* The horizon of this species in Ohio is considered by Mr. WHITFIELD (Annals of the New York Academy of Sciences, vol. ii, p. 212; 1882), the equivalent of the Marcellus shales of New York, on account of its association with a few species of the New York fauna. The character of the sediments is, however, altogether different, the rocks at Delaware, Ohio, being largely calcareous. They lie at the top of the Corniferous series in that State and are included in this series by Professor ORTON, in his First Report of the Third Geological Survey of Ohio, 1890. The association of the species in the Province of Ontario is invariably with characteristic forms of the Corniferous fauna.

* Palæozoic Fossils, vol. ii, p. 18. 1874.

GENUS CHONOPECTUS, GEN. NOV.

PLATE XVB, FIGS. 20-23; AND PLATE XVI, FIGS. 17, 31.

1854. *Chonetes*, NORWOOD and PRATTEN. Journal Acad. Nat. Sci. Phila., vol. ii, p. 25.
1858. *Chonetes*, HALL. Geological Survey of Iowa, vol. i. pt. ii, p. 517, pl vii, fig. 1.
1883. *Chonetes*, HALL. Second Ann. Rept. N. Y. State Geologist, pl. xvii, fig. 17.

This name is proposed for the species, *Chonetes Fischeri*, Norwood and Pratten, a large, normally concavo-convex shell, with a sub-semicircular outline; occurring in the oolitic limestone and yellow sandstone of the Burlington beds of Iowa. In this species the cardinal margin of the pedicle-valve bears a row of erect spines, as in CHONETES. The beak is often compressed or distorted in such a manner as to leave a flattened area, which resembles, and probably is a cicatrix from attachment in early growth. This character is more prominent in some individuals than in others, and appears to have become considerably obscured by the later growth of the shell. The surface ornamentation is also peculiar: the shell bearing a double oblique series of concentric lines, which give to the surface the appearance of the engraving on a machine-turned watch case. These lines are wrinkles rather than striæ, and are strongest over the umbonal and central region, where traces of them may sometimes be observed on internal casts of the valves. The wrinkles are crossed by a normal series of very fine concentric growth-lines, and beneath these, but not always exposed, are exceedingly fine, crowded, radiating striæ, usually very much interrupted in their course from beak to margin, and often flexuous and irregular. Sometimes the surface is entirely free from the double series of concentric wrinkles, and marked only by the fine radiating and concentric striæ.

The internal muscular impressions of the species have not been fully determined. Casts of the pedicle-valve show the impression of a short median septum dividing two broad obcordate flabelliform muscular scars, from the outer margin of which sometimes originates a series of irregularly radiating furrows or ridges, which were probably of vascular origin. Impressions of a very narrow cardinal area and exceedingly small hinge-teeth are also seen on internal casts of this valve.

GENUS CHONETELLA, WAAGEN. 1884.

1884. *Chonetella*, WAAGEN. Mem. Geol. Survey of India; Palæontologia Indica, Series xiii. vol. i. No. 4, p. 657, pl. lxxxi, figs. 3-8.

DIAGNOSIS. Shell small, normally concavo-convex. Surface rounded, with radial striæ; cardinal area narrow; deltidium, cardinal spines and teeth as in CHONETES. In the pedicle-valve the adductor impressions are elongate, and are partially enclosed by the larger cardinals. The brachial valve has a small trilobed cardinal process, which is continued into a low median septum. The muscular area is quadripartite and very distinct. The brachial ridges are sharply defined and appear to originate near the outer extremities of the posterior adductors, making a broad outward, and a more abrupt inward curve completing one volution. Surface in the pallial region strongly papillose.

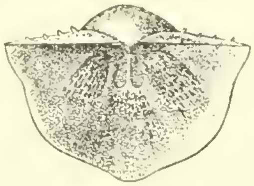

FIG. 26. *Chonetella nasuta.* After WAAGEN.

Type, *Chonetella nasuta*, Waagen. Upper Carboniferous.

OBSERVATIONS. Dr. WAAGEN has proposed this division for a single species from the Productus limestone of India. Aside from the broadly curved brachial ridges, its characters are so strongly chonetoid as to render its separation from CHONETES exceedingly difficult.* The author surmises that some small shells figured by DAVIDSON† and regarded by him as varieties of *Productus longispinus*, from the Carboniferous shales of Lanarkshire, Scotland, belong to the same group.

* The *trilobed* cardinal process is described in its anterior aspect only, and it is quite probable that upon its posterior face it would be found more similar to that of CHONETES. The crural plates are very obscure, making the process appear free and erect; but this is also true of some species of CHONETES, *e.g.*, *Chonetes coronata*, Conrad.

† Carboniferous Brachiopoda, pl. xxxv, figs. 18, 19.

GENUS STROPHALOSIA, KING. 1844.

PLATE XVB, FIGS. 21-37; PLATE XVI, FIGS. 12, 16, 30, 38, 42; PLATE XVII, FIGS. 10-15, 50, 51; AND PLATE XVIIA, FIGS. 1-9.

1839. *Spondylus*, MUNSTER. Beitr. zur Petrefactenkunde, Heft i, p. 43, pl. iv, fig. 3.
1842. *Orthis*, GEINITZ. Neues Jahrbuch für Min., etc., p. 578, pl x, figs. 12, 13.
1843. *Strophomena*, HALL. Geology of N. Y.: Rept. Fourth District, p. 189, fig. 4.
1844. *Strophalosia*, KING. Annals and Magazine of Natural History, vol. xiv, p. 313.
1845. *Leptænalosia*, KING (MS.). In de Verneuil's Géol. de la Russ., etc., vol. ii, p. 281.
1846. *Strophalosia*, KING. Annals and Magazine of Natural History, vol. xvii, p. 92.
1847. *Orthothrix*, GEINITZ. Bull. Imp. Soc. des Nat. de Moscou, vol. xx, p. 84.
1847. *Productus*, DE KONINCK. Monographie des genres Productus et Chonetes, pp. 148, 150, pl. xi, fig. 4; pl. xv, figs. 4, 5.
1848. *Orthothrix*, GEINITZ. Verstein. der deutsch. Zechst.-gebirg., p. 14, pl. v, figs. 27-37; pl. vi, fig. 20.
1850. *Strophalosia*, KING. Monogr. Permian Fossils of England, p. 93, pl. xii, figs. 1-33.
1853. *Strophalosia*, DAVIDSON. Introd. British Fossil Brachiopoda, p. 115.
1855. *Leptæna*, MCCOY. British Palæozoic Fossils, p. 457.
1857. *Strophalosia*, DAVIDSON. British Permian Fossils, p. 38, pl. iii, figs. 1-10, 19-41.
1857. *Productella*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 171.
1861. *Strophalosia*, GEINITZ. Dyas, p. 93, pls. xvii, figs. 1-19, 21-39; xviii, figs. 1-20; xix, figs. 2-6, 25.
1863. *Strophalosia*, A. WINCHELL. Proc. Acad. Nat. Sci., Phila., vol. 15, p. 4.
1866. *Crania*, A. WINCHELL. Rept Lower Peninsula of Michigan, p. 92.
1867. *Chonetes*, HALL. Palæontology of N. Y., vol. iv, p. 143, pl. xxii, figs. 29-43.
1867. *Productella*, HALL. Palæontology of N. Y., vol. iv, p. 160, pl. xxiii, figs. 12-24.
1868. *Aulosteges*, WHITE and ST. JOHN. Trans. Chicago Acad. Sci., vol. i, p. 118, fig. 2.
1874. *Strophalosia*, DERBY. Bull. Cornell University, vol. i, No. 2, p. 45, pls. iii, iv, viii, ix.
1883. *Chonetes* (*Productella*, *Strophalosia*), HALL. Ann Rept. N. Y. State Geologist for 1882, pl. xvi (47), figs. 12, 16, pl. xvii (48), figs. 10-15, 50, 51.
1884 *Productus* (*Productella*), WALCOTT. Palæontology Eureka District, p. 131, pl. xiv, fig. 2.
1884. *Strophalosia*, WAAGEN. Salt-Range Fossils; Brachiopoda, pp. 640-657, pl. lxiii, figs. 2-8; pl. lxiv, figs. 1-9; pl. lxv, figs. 1-9.
1889. *Productella* (*Strophalosia*), WHITEAVES. Contributions Can. Geol., vol. i, p. 112, pl. xvi, figs. 1, 2.

DIAGNOSIS. Shells productoid in general form; a cicatrix, usually apparent on the umbo of the pedicle-valve, indicates that they were attached to foreign bodies by the substance of the shell. Both valves have a well defined area and covered delthyrium, these features being much the more conspicuous in the pedicle-valve. In this valve the teeth are prominent, but not supported by lamellæ; the muscular arrangement is the same as in PRODUCTUS, though the cardinal impressions are relatively larger and more elongate, extending beyond the limits of the central adductors.

In the brachial valve the cardinal process is erect, bifid on its anterior, and quadrifid in its posterior face. It is supported on each side by short, arched crural plates, and is continued into a median septum which extends for half

the length of the valve. Muscular impressions small, quadruple, not dendritic. the interior pair being sharply raised. The brachial ridges originate from between the adductor scars, curving gently outward, recurving, at first gradually and then abruptly to their anterior limit; then turning suddenly backward, and again inward horizontally, meeting the median septum near its anterior extremity.

Surface of the pedicle-valve covered with spines, which near the beak are often curved backward, embracing some external object. In some species all the spines of the valve have evidently been at least of accessory importance in effecting its attachment. The surface of the brachial valve may be either spinous, lamellose or smooth.

Type, *Orthis excavata*, Geinitz, = *S. Goldfussi*, (Münster) Davidson. Permian of Europe.

Observations. The existence of cardinal areas, delthyria, and articulation, the form of the brachial ridges, and the substantial attachment of the shell either in youth or throughout its existence, make an association of characters which serve to readily distinguish this genus from its allies. The genus Strophalosia is not very abundantly represented in species; all the generic characters described are typically developed only in the Permian members of the group.* In the earlier forms of the Devonian and Lower Carboniferous, the expression of the shells is often quite distinct from the later species, though not affording any satisfactory basis for separation. The existence of an articular system and of cardinal areas is not sufficient of itself to distinguish Strophalosia from Productella; and it will therefore be necessary to base distinctive generic value upon the umbonal attachment of the former.

In the mature condition of the Permian species the umbonal cicatrix of the pedicle-valve is often obscure, having become somewhat obliterated, during their probably free condition near, and at maturity. As observed in the diagnosis, the spines in such species are frequently turned backward in such a manner as to leave the impression that they were certainly flexible, and prob-

* See Waagen, Salt-Range Fossils; Brachiopoda, p. 640.

ably attached to some extraneous body, a phenomenon which has been noticed in PRODUCTUS (*P. complectens* and other species). In some of the earlier species of this genus, *e.g.*, *S. radicans*, Winchell, of the Hamilton group, *S. scintilla*, Beecher, of the Choteau limestone, and *S. Keokuk*, Beecher, of the Keokuk group, the entire shell is small, and the pedicle-valve attached by almost its entire surface; the spines on these valves are all attached, creeping like rootlets in irregular, flexuose lines over the surface of the host. A Permian form similar to these was described by Professor KING,* under the name *S. parva*, which may be the young of some of the larger associated species; but the Hamilton and Lower Carboniferous forms can not, with our present knowledge, be regarded as undeveloped shells. The affinities of STROPHALOSIA with both CHONETES and AULOSTEGES, serve to make the transition from the chonetoid shells to PRODUCTUS a complete and very easy one.

No satisfactory subdivision of the species of STROPHALOSIA has been made. Dr. WAAGEN described a number of new species from the Productus limestone of India, and proposed a grouping therefor upon the basis of the general form of the shell. It may be suggested that a good basis for a provisional subdivision of the genus can be found in the character of the external surface of the brachial valve. This valve is *spiniferous*, as in *S. excavata*, Geinitz, and the majority of the species; *lamellose*, or covered with concentric lamellæ or varices of growth, as in *S. lamellosa*, Geinitz; or *smooth*, as in *S. Leplayi*, Geinitz, *S. plicosa*, Waagen, *S. radicans*, Winchell, etc.

In American faunas STROPHALOSIA is of rare occurrence. The following species only may be safely referred to the genus: *Producta truncata*, Hall, of the Marcellus and Hamilton faunas; *Chonetes muricatus*, and *Productella hystricula*, Hall, of the Chemung group; *Crania radicans*, Winchell, from the Hamilton group; *S. numularis*, Winchell, of the Marshall group; *S. scintilla*, Beecher, of the Choteau limestone; *S. Keokuk*, Beecher, from the Keokuk group, and probably *Aulosteges spondyliformis*, White and St. John, from the Coal Measures. To these may be added *S. Rockfordensis*, sp. nov., from the Upper Devonian of Iowa. None of these species, however, show the typical development of the interior found in the Permian forms.

* Monograph of the Permian Fossils of England, p. 102, pl. xii, fig. 33.

Mr. DAVIDSON, in his Devonian Brachiopoda,* has referred the Devonian species, *Orthis productoides*, Murchison, to STROPHALOSIA, but it shows no evidence of attachment, and more properly belongs to PRODUCTELLA. Professor KING had previously made a similar reference of this species,† and included in the same genus *Productus subaculeatus*, Murchison, an unattached species, subsequently taken as the type of PRODUCTELLA.

GENUS DAVIESIELLA, WAAGEN. 1884.

1823. *Productus*, SOWERBY. Mineral Conchology, vol. iv, pp. 31, 329.
1837. *Leptæna*, FISCHER. Oryctogr. du Gouvern. de Moscou, p. 143, pl. xxii, fig. 1.
1842. *Producta*, D'ARCHIAC and DE VERNEUIL. Trans. Geol. Soc. London, 2nd Ser., vol. vi, pt. ii, p. 397.
1846. *Chonetes*, DE KEYSERLING. Beob. Reise in das Petschora-land, p. 214, pl. vi, fig. 1.
1847. *Chonetes*, DE KONINCK. Monogr. du Genre Chonetes, p. 189, pl. xix, fig. 1.
1861. *Chonetes*, DAVIDSON. British Carboniferous Brachiopoda, p. 180, pl. xlv, figs. 1–7.
1862. *Productus*, DAVIDSON. Brit. Carb. Brachiopoda, pp. 275, 277, pl. xlvi, fig. 1; pl. lv, figs. 6–10.
1884. *Daviesiella*, WAAGEN. Mem. Geol. Surv. India; Palæontologia Indica, Ser. xiii, vol. i, No. 4, p. 613.

Dr. WAAGEN writes:

"I create this genus for the reception of such forms as *Productus Llangollensis*, Dav., and *Prod. comoides*, Sow., which are characterized by cardinal teeth and a second pair of adductor impressions in the ventral valve. The other characters are like those of PRODUCTUS. Mountain limestone."— *op. cit.*

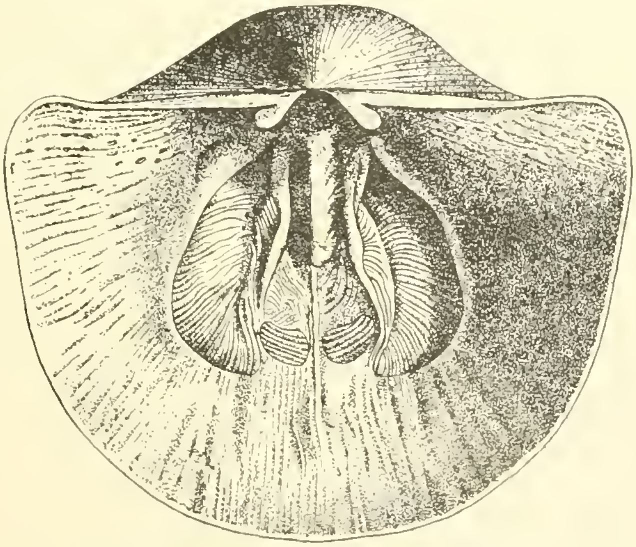

FIG. 27. *Productus* (*Daviesiella*) *Llangollensis*, Davidson. After DAVIDSON.

* Page 97.

† Permian Fossils, p. 95.

The two species named are large, ponderous shells, having the cardinal area and teeth conspicuously developed, the external surface covered with fine radiating striæ, and devoid of spines The existence of the secondary muscular scar in the pedicle-valve can hardly be regarded as a distinctive feature, since it is also well defined in some other species of PRODUCTUS. The form and size of the shells, the arrangement of the muscular scars, and their dendritic markings, and the structure of the cardinal process, all show the very close relationship of these species to the typical forms of PRODUCTUS. It will be difficult to find features of intrinsic importance upon which to justify the separation of these fossils from PRODUCTELLA, unless it be in the spineless surface; and yet the general form and expression of the shells is so different from what we are accustomed to meet with in that distinctively Devonian genus, that for the sake of homogeneity in the grouping, it may be well to retain for them this designation.

Both *P. Llangollensis* and *P. comoides* are from the Welsh Coal Measures, and may be regarded as the final expression of that combination of characters constituting PRODUCTELLA in earlier faunas.

Genus AULOSTEGES, von Helmersen. 1847.

PLATE XVII, FIGS. 47-49.

1845. *Orthis*, de Verneuil. Géol. Russ. d'Europe et des Mont. l'Oural, vol. ii, p. 198, pl. xi, fig. 5.
1847. *Aulosteges*, von Helmersen. Neues Jahrb. für Mineral., p. 330.
1847. *Aulosteges*, von Helmersen. Bull. Acad. Imp. Sci. St. Petersbourg, vol. vi, p. 135, pl. vi, fig. 12.
1850. (?) *Strophalosia*, King. Monogr. Permian Fossils England, p. 93.
1853. *Aulosteges*, Davidson. Introd. British Fossil Brachiopoda, p. 116, pl. ix, figs. 212-216.
1848. *Aulosteges*, Shumard. Trans. St. Louis Acad. Science, vol. i, p. 292, pl. xi, fig. 5.
1861. *Strophalosia*, Geinitz. Dyas, Heft i, p. 93.
1862. *Aulosteges*, Davidson. Quarterly Journal Geological Society, vol. xviii, p. 33, pl. ii, fig. 7.
1863. *Aulosteges*, de Koninck. Fossiles paléozoiques de l'Inde, p. 41, pl. xii, fig. 7.
1883. *Aulosteges*, Hall. Ann. Rept. N. Y. State Geologist for 1882, pl. (xvii) 48, figs. 47-49.
1884. *Aulosteges*, Waagen. Palæontologia Indica; Salt-Range Fossils, vol. i, pt. iv, p. 661, pl. lxii, figs. 1-4; pl. lxiii, fig. 1.

Diagnosis. Shell productiform in general aspect, somewhat depressed, not attached. On the pedicle-valve the cardinal area is prominently developed, frequently somewhat distorted; the delthyrium is closed by a convex deltidium which is covered with little tubercles or spinules. Cardinal teeth rudimentary or absent. In the brachial valve the cardinal area is linear, the cardinal process large, quadrifid; its base being surrounded by a strong deltidial callosity. Brachial ridges extending nearly to the anterior margin and abruptly incurving. Otherwise the interior impressions are as in Productus. Surface of both valves thickly set with spines.

Type, *Aulosteges variabilis*, von Helmersen,= *Orthis Wangenheimi*, de Verneuil. Permian of Russia.

Observations. It was early observed by King that Aulosteges formed a connecting link between Strophalosia and Productus. The constant presence of the cardinal area and the usual absence of the hinge-teeth, show the correctness of this observation as far as it bears upon the structure of these genera. Aulosteges is chiefly if not wholly of Permian age, and it may perhaps be better to regard it as a descendant or offshoot from Strophalosia; showing the obsolescence of teeth, which is the tendency toward the prevailing brachiopod type of that and the preceding fauna. The specific representation of Aulosteges is quite meager. The original species, *A. Wangenheimi*, de Verneuil (which, according to King, Davidson and others, is identical with, and therefore has

priority over VON HELMERSEN'S *A. variabilis*), is from the Permian of northern Russia. DAVIDSON recognized no species in the British formations, though KING, in 1856,* considered his *Productus umbonillatus* (=*P. latirostratus*, Howse) an AULOSTEGES. DAVIDSON described *A. Dalhousii*, and WAAGEN *A. Medlicottianus*, from the Permian of the Salt-Range of India. In America but two species have been referred to this genus, namely, *A. Guadalupensis*, G. C. Shumard, from the Guadalupe Mountains of Texas, a very imperfect shell, insufficiently illustrated, but showing a high cardinal area; and *A. spondyliformis*, White and St. John, from the Upper Carboniferous beds of Iowa; a form which it would be difficult to separate from STROPHALOSIA on the basis of the features given in the original description and figures.

Mr. R. ETHERIDGE, Jr., in discussing "Adherent Carboniferous Productidæ,"† has figured (figs. 2–4) and described a shell which he regards as CHONETES, adherent by its spines (figs. 2, 3) and the outer surface of the pedicle-valve to foreign objects. This discussion is one of great interest and will be referred to at greater length in regard to some important points established in this and a previous paper on the same subject, by Mr. ETHERIDGE. There is some room for doubt, however, whether these shells should be regarded as belonging to the genus CHONETES. The individual represented in figure 4 of his work, a pedicle-valve with area and delthyrium, attached by its outer face, and covered with spines creeping over the surface of the host, can hardly be anything but a STROPHALOSIA of the type of *S. radicans*, *S. Keokuk* and *S. scintilla*. The subject of the other figures, a shell in which one of the cardinal spines encircles a spine of PRODUCTUS, is quite imperfect but has a more decided chonetiform expression. It will be interesting to learn more of this peculiar form.

* Annals and Magazine of Natural History.

† Quarterly Journal Geological Society, vol. xxxiv, p. 498. 1878.

GENUS PRODUCTUS, SOWERBY. 1812.

PLATE XVIIA, FIGS. 13-24; PLATE XVIII, FIGS. 6-19; AND PLATE XIX, FIGS. 1-23.

1778. *Anomia*, DA COSTA. British Conchology.
1780. *Gryphites*, WALCH. Beitr. zur Geschichte der Gryphiten.
1785. *Anomia, Pyxis*, CHEMNITZ. Neues Systemat. Konchylien-Kabinet, vols. vii, viii.
1789-92. *Arca*, BRUGUIÈRE. Hist. Naturelle des Vers testacés.
1793. *Anomia*, URE. History Rutherglen and East Kilbride, p. 314.
1801. *Tridacna*, LAMARCK. Animaux sans Vertèbres.
1809. *Anomites*, MARTIN. Petrefacta Derbiensia, pls. xv, xvi, xxii, xxxii, xxxiii, xxxvi, xxxvii.
1811. *Trigonia*, PARKINSON. Organic Remains, vol. iii, pl. xii, fig. 11.
1812-14. *Productus*, SOWERBY. Mineral Conchology.
1826. *Protonia*, LINCK. Handb. d. physikal. Erdbeschreib.
1826-33. *Leptæna*, GOLDFUSS. Petrefacta Germaniæ.
1828. *Leptæna*, DALMAN. Uppställn. och Beskrifn. Sver. funne Terebrat.
1829. *Terebratula*, RANG. Manuel de l'hist. natur. des Mollusques, etc.
1830. *Mytilus*, FISCHER. Oryctogr. du Gouv. de Moscou, p. 181, pl. xix, fig. 4.
1831. *Arbusculites*, MURRAY. Acc't of A. argentea from Carb. limest.
1835. *Productus*, CONRAD. Trans. Geol. Soc. Penna., vol. i, p. 268, pl. xii, fig. 5.
1836. *Productus*, MORTON. American Journ. Sci. and Arts, p. 153, pl. ii, fig. 2; pl. xxxix, figs. 38, 39.
1836. *Producta, Pinna*, PHILLIPS. Geology of Yorkshire, vol. ii.
1837. *Leptæna*, FISCHER. Oryctogr. du Gouv. de Moscou, p. 144, pl. xxi.
1838. *Productus*, SHEPARD. Am. Journ. Sci. and Arts, vol. xxxiv, p. 153.
1840. *Lima*, VON BUCH. Kärsten's Archiv. für Mineral. Geogn. etc., p. 60.
1840. *Pecten*, EICHWALD. Bull. scientif. de l'Acad. de St. Petersbourg, vol. vii, p. 86.
1841. *Clavagella*, GOLDFUSS. Petrefacta Germaniæ, vol. ii, p. 285, pl. clx, fig. 17.
1841. *Leptæna*, J. DE C. SOWERBY. Mineral Conchology, vol. vii, pl. 615.
1842. *Productus*, D'ORBIGNY. Voyage dans l'Amerique Meridionale Palæontology, pp. 51-55, pl. iii, figs. 24-26, pl. iv, figs. 1-9, 12, 13, pl. v, figs. 4-10.
1844. *Leptæna*, MCCOY. Synopsis Charact. Carbon. Limest. Ireland, pl. xix, fig. 12.
1844. *Strophomena*, POTIEZ and MICHAUD. Galerie des Mollusques de Douai, vol. ii, pl. xlii, fig. 5.
1845. *Productus*, DE VERNEUIL. Geol. de la Russie et des Mont. de l'Oural, p. 246.
1845. *Productus*, DE VERNEUIL. Travels in North America, vol. ii, p. 221.
1847. *Productus*, DE KONINCK. Recherches sur les Animaux fossiles; Monogr. du genre Productus.
1851. *Leptæna* (partim), DE KONINCK. Descr. des Animaux. Foss. du Terrain Carb. de Belgique.
1852. *Productus*, OWEN. Geol. Surv. Wisconsin, Iowa and Minn., pp. 103, 136, 584, pl. v, figs. 1, 3.
1852. *Productus*, HALL. Stansbury's Expl. Great Salt Lake Region, p. 412, pl. iii, figs. 3, 5, 6.
1853. *Productus*, SHUMARD. Marcy and McClellan's Expl. Red River of Louisiana, p. 201, pl. i, fig. 5; pl. ii, fig. 1.
1854. *Productus*, NORWOOD & PRATTEN. Journ. Acad. Nat. Sci. Phila., vol. iii, pp. 6-20, pl. i, figs. 1-3, 5, 6, 8-11; pl. ii, fig. 1.
1855. *Producta*, MCCOY. British Palæozoic Fossils, p. 473.
Productus of authors generally.
1855. *Productus*, SCHIEL. Rept. Expls. and Survs. from the Mississippi River to the Pacific Ocean, pl. i, fig. 3; pl. ii, figs. 4, 5.
1855. *Productus*, SHUMARD. Geol. Rept. Missouri, pp. 201, 216, pl. c, fig. 10.
1856. *Productus*, HALL. Rept. Expls. and Survs. from Miss. River to Pacific Ocean, vol. iii, p. 103, pl. ii, figs. 16, 17.
1857. *Productus*, PROUT. Trans. St. Louis Acad Science, vol. i, p. 43, pl. ii, figs. 1-16.
1857. *Productus*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., p. 180.

1858. *Productus*, HALL. Geol. Survey Iowa, vol. i, part 2, pp. 635–639, 674, 675, 712, pl. xii, fig. 3; pl. xix, figs. 1–4; pl. xxiv, figs. 1–3; pl. xxviii, figs. 3–4.
1858. *Productus*, HALL. Trans. Albany Inst., vol. iv, pp. 12, 13.
1858. *Productus*, SWALLOW. Trans. St. Louis Acad. Sci., vol i, pp. 181, 182, 215–217.
1858. *Productus*, SHUMARD. Trans. St. Louis Acad. Sci., vol. i, pp. 290–292, pl. xi, fig. 8.
1858. *Productus*, ROGERS. Geol. Penna., vol. ii, part 2, p. 833.
1858. *Productus*, MARCOU. Geology North America, pp. 45–48, pl. v, figs. 3–6; pl. vi, figs. 1, 3–7, 12.
1859. *Productus*, MEEK and HAYDEN. Proc. Acad. Nat. Sci. Phila., pp. 25, 26.
1860. *Productus*, MEEK. Proc. Acad. Nat. Sci. Phila., vol. xii, p. 309.
1860. *Productus*, MEEK and WORTHEN. Ibidem, pp. 450, 451.
1860. *Productus*, WORTHEN. Trans. St. Louis Acad. Sci., vol. i, p. 570.
1860. *Productus*, WHITE. Journ. Boston Soc. Nat. Hist., p. 230.
1860. *Productus*, SWALLOW. Trans. St. Louis Acad. Sci., vol. i, pp. 640, 641.
1860. *Productus*, McCHESNEY. Descrip. New Species Palæoz. Foss., pp. 34–40.
1861. *Productus*, SALTER. Quart. Jour. Geol. Soc. Lond., vol. xvii, p. 64.
1861. *Productus*, NEWBERRY. Ives' Rept. Expl. Colorado River of the West, pp. 121–125, pl. i, fig. 7; pl. ii, figs. 1–10.
1861. *Productus*, MEEK & WORTHEN. Proc. Acad. Nat. Sci. Phila., p. 142.
1862. *Productus*, WHITE. Proc. Bost. Soc. Nat. Hist., vol. ix, p. 29.
1863. *Productus*, SWALLOW. Trans. St. Louis Acad. Sci., vol. ii, pp. 91–94.
1863. *Producta*, A. WINCHELL. Proc. Acad. Nat. Sci. Phila., vol. xv, p. 4.
1864. *Productus*, MEEK. Palæontology of California, vol. i, p. 11, pl. ii, fig. 4.
1865. *Productus*, A. WINCHELL. Proc. Acad. Nat. Sci. Phila., pp. 112–115.
1866. *Productus*, GEINITZ. Carbon and Dyas in Nebraska, pp. 52, 54, 81, pl. iv, figs. 1–11.
1866. *Productus*, MEEK & WORTHEN. Geol. Surv. Illinois, vol. iii, pp. 280, 297, 320, pl. xx, fig. 5; pl. xxiii, fig. 4; pl. xxvi, fig. 4.
1867. *Productus*, HALL. Palæontology New York, vol. iv, p. 146.
1867. *Productus*, HALL. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 245.
1868. *Productus*, McCHESNEY. Trans. Chicago Acad. Sci., vol. i, pp. 24–27, pl. i, figs. 7–11; pl. vi, fig. 1.
1868. *Productus*, MEEK & WORTHEN. Geol. Surv. Illinois, vol. iii, p. 528, pl. xx, fig. 7.
1870. *Producta*, A. WINCHELL. Proc. American Philos. Soc., vol. xii, p. 249.
1871. *Productus*, MEEK. Palæontology Eastern Nebraska, pp. 159–169, pl. i, fig. 14; pl. ii, figs. 2, 5, 6; pl. iv, figs. 5, 6; pl. v, figs. 6, 7, 11, 13; pl. vi, figs. 6, 7; pl. viii, figs. 6, 9, 10, 13.
1873. *Productus*, WORTHEN. Geol. Surv. Illinois, vol. v, p. 569; pl. xxv, fig. 9.
1873. *Productus*, MEEK & WORTHEN. Ibidem, p. 569, pl. xxv, figs. 8, 10, 13.
1874. *Productus*, DERBY. Bull. Cornell Univ., vol. i, pp. 47, 49, 51, 54, 56, 59, pl. i, figs 2, 10–13, 15; pl. ii, figs. 14, 17; pl. iii, figs. 20, 41–44, 46–49; pl. iv, figs. 1–4, 7–11, 13, 16; pl. vi, figs. 1, 4–7, 9, 17, 18; pl. vii, figs. 5–7, 15, 16; pl. ix, figs. 12, 13.
1875. *Productus*, MEEK. Palæontology Ohio, vol. ii, p. 282, 283, pl. x, figs. 3, 4.
1875. *Productus*, WHITE. Wheeler's Geogr. and Geol. Surv. west 100th meridian, pp. 83, 109–116, 120, pl. v, fig. 6; pl. vii, figs. 1, 2; pl. viii, figs. 1–6.
1876. *Productus*, MEEK. Bull. U. S. Geol and Geogr. Surv. Terr., vol. ii, p. 354, pl. i, fig. 1.
1876. *Productus*, DERBY. Bull. Mus. Comp. Zool., vol. iii, pp. 280, 281.
1876. *Productus*, NEWBERRY. Rept. Macomb's Expl. Exped. from Santa Fé to junction of Grand and Green Rivers of the Great Colorado of the west.
1877. *Productus*, HALL & WHITFIELD. U. S. Geol. Expl. 40th Parallel, vol. iv, pp. 265–268, pl. v, figs. 3–12.
1877. *Productus*, MEEK. Ibidem, pp. 64–67, 69, 72–76, pl. vii, figs. 3–8; pl. viii, figs. 2–4.
1878. *Productus*, DAWSON. Acadian Geology, third ed., pp. 296, 297.
1880. *Productus*, WHITE. Proc. U. S. Nat. Mus., p. 46.
1881. *Productus*, WHITE. Tenth Ann. Rept. Indiana State Geologist, p. 148, pl. viii, figs. 7, 8.

1882. *Productus*, WHITFIELD. Bull. Amer. Mus. Nat. Hist., vol. i, No. 3, pp. 46, 47. pl. vi, figs. 6-12.
1882. *Productus*, WHITE. Eleventh Ann. Rept. Indiana State Geol., p. 373, pl. xlii, figs. 1-3.
1883. *Productus*, HALL. Twelfth Ann. Rept. Indiana State Geol., pp. 325, 326, pl. xxix, figs. 6, 7.
1883. *Productus*, HALL Rept. N. Y. State Geol. for 1882, plates (xviii) 49; (xix) 50.
1883. *Productus*, WHITE. Twelfth Ann. Rept. U. S. Geol. Surv. Terr., p. 132, pl. xxxvi, fig. 1.
1884. *Productus*, WHITE. Thirteenth Ann. Rept. Indiana State Geol., pp. 122-126, pl. xxiv, figs. 1-11; pl. xxv, figs. 1-5; pl. xxvi, figs. 1-3; pl. xxvii, figs. 1-3.
1887. *Productus*, HERRICK. Bull. Denison Univ., vol. ii, pp. 47-49, pl. ii, figs. 25-30.
1888. *Productus*, HERRICK. Ibidem, vol. iii, pp. 31-34, pl. i, figs. 24, 26; pl. iii; figs. 20, 22-24; pl. vii, figs. 11, 20; pl. x, fig. 6, vol. iv, pp. 19-23, pl. iii, figs. 15, 17, 19; pl. x, figs. 24, 25; pl. xi, figs. 26, 29.
1888. *Productus*, KEYES. Proc. Acad. Nat. Sci. Phila., Extract, pp. 6, 7.

Our knowledge of the generic characters of this group has not greatly progressed during the last forty years. Though with the advance of investigation the specific representation of the genus has become enormous,* the generic value of PRODUCTUS was nearly as well understood, if not so closely restricted, at the date of the elaborate discussions of the genus by DE VERNEUIL (Géologie de la Russie, etc., 1845), and DE KONINCK (Monographie du genre Productus, 1847), as at the present time. The generic divisions which have been since proposed for species then referred to PRODUCTUS seem to have but limited value or to represent no fundamental variation from the type of the old genus. The following diagnosis can not, therefore, vary materially from those given by earlier writers.†

DIAGNOSIS. Shell free, concavo-convex, the valves usually produced anteriorly; outline semicircular, sometimes transversely elongate. Pedicle-valve convex, sometimes geniculated, occasionally with a median sinus. Cardinal extremities frequently auriculate. Umbo inflated, with apex incurved. Hinge-line straight, cardinal area and teeth absent or rudimentary. External surface usually with more or less prominent radiating ribs which are crossed, especially in the umbonal region, by concentric lines or wrinkles; rarely smooth or finely striated, often studded with spines varying in size and abundance. These spines are

* DE KONINCK described sixty-one species in his Monograph in 1847, not recognizing the genus STROPHALOSIA, King, 1844, nor indicating the various subdivisions which subsequent writers have erected into genera or subgenera. In MILLER'S North American Geology and Paleontology (1889) eighty species of PRODUCTUS and twenty-seven species of PRODUCTELLA are given as occurring in the Palæozoic rocks of this continent alone.

† WAAGEN, after his elaborate study of the species of the PRODUCTUS limestone of India (1884), says: "I have nothing new to add to them [the generic characters]."

frequently scattered irregularly over the surface, generally strongest and disposed with greatest regularity upon the cardinal extremities, and sometimes occurring only in this region. They are hollow and appear to have communicated with the interior cavity of the shell. On the interior of the valve is a narrow median ridge, separating the two dendritic impressions of the adductor muscles; outside and in front of these are two broadly flabellate, longitudinally striated scars of the cardinal muscles. In the pallial region are sometimes found traces of spiral cavities, which were occupied by the fleshy arms.*

The brachial valve is operculiform, more or less concave or almost flat over the visceral area. Cardinal area, sockets and crural plates absent or rudimentary; cardinal process strong, curved or erect, extending far above the hinge-line; its inner face is divided into two lobes by a longitudinal furrow, and each of these parts is deeply divided at its extremity, giving the process in this aspect a quadrilobed appearance. As viewed from the posterior or outer face it is strongly trilobed, the inner members of the lateral lobes coalescing to form a very prominent apophysis. The process is continued over the interior of the shell as a longitudinal septum, dividing the impressions of the adductor muscles. The latter are strongly dendritic and rarely divisible into anterior and posterior elements. The brachial ridges† take their origin from near the post-lateral margins and nearly enclose a sub-circular, smooth or granulose area. The internal surface of this valve is strongly postulose, and in the pallial region frequently spinous.

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* See DAVIDSON, British Carboniferous Brachiopoda, pl. xxxvii, fig. 1. 1861.

† WAAGEN says (Productus-limestone Fossils, p. 611): "A passage in Professor NEUMAYR's paper [Neues Jahrbuch für Mineralogie, 1883, vol. ii, p. 27], which is of very great importance, I must quote here more in detail. He says, a chief objection of DAVIDSON's against the opinion that these ridges form a part of the brachial apparatus is the existence of spiral impressions which are to be found in the ventral valve of some specimens of PRODUCTUS, and which beyond any doubt are impressions of the spirally enrolled arms of the animal. Now, as these impressions show not the slightest accordance with the brachial ridges [reniform impressions], Mr. DAVIDSON concludes that these latter cannot be taken as belonging to the brachial apparatus. 'I cannot concur,' says Professor NEUMAYR, 'in this argument. The greatest number of the now living Brachiopods have arms showing a double curve; and if such were, as is probable, present in PRODUCTUS, these features (the ridges in the one and the spiral impressions in the other valve) are in no way difficult to explain; on the contrary they indicate very accurately the direction and the manner in which the arms extended in PRODUCTUS. They run first along the descending, then along the reascending branch of the ridges, were then bent back over the descending branch, and curled in a spiral coil, which caused the impression in the ventral valve. Thus, in their general shape, these arms very nearly agree with those occurring in TEREBRATULA and WALDHEIMIA, though in proportion and direction of the different parts certain differences exist.' This deduction is of very great systematic importance."

Shell substance fibrous, strongly punctate.

Type, *Productus Martini*, Sowerby, = *Anomites productus*, Martin, = *Anomites semireticulatus*, Martin, = *Productus semireticulatus*, Martin. Lower Carboniferous limestone to Coal Measures.

Observations. It is the usage of some systematists to regard the genus Productus as a starting point in the classification of the articulate brachiopoda on account of the usual absence of the cardinal area and teeth. These are features which are unquestionably in an obsolescent condition. It is rarely, however, that some trace of them is not discernible, and it has been observed by various writers, that they are sometimes well-defined, and that too in species where they are normally wanting. For example, they may be present in the species *Productus semireticulatus* and *P. Nebrascensis*. In these features Productus is degenerate, but this degeneracy has apparently not extended to other points of structure, and the genus certainly lacks the simplicity of plan in its structure so apparent in Orthis. Its late appearance in the Palæozoic and its close kinship to the Chonetes-stock is evidence of its derivation from that source. The earliest phase of the productoid type, which is abundantly developed in the Devonian, and which has been distinguished by the name of Productella, retains the articulating processes and cardinal area with persistence throughout the period immediately preceding the appearance of normal Productus. These features are, however, always more or less obscure, and manifestly approaching desuetude. Leaving for the present the consideration of this and the other generic or subgeneric divisions, which have been taken from Productus, we have, in this genus, to deal with a very homogeneous group of fossils.

A grouping of the species of Productus was proposed by de Verneuil in 1845,* and this was amended and somewhat amplified by de Koninck in 1847.† Dr. Waagen, in his magnificent treatise on the Producti of the Salt-Range, is the latest writer who has discussed the genus at length, and has adopted this classification with some modifications and additions; it is evident that no

* Géologie de la Russie, p. 253.

† Monographie du genre Productus, p. 29.

better means for the arrangement and simplification of this group can now be offered. Some of the divisions made by the French authors must be abandoned, since the forms on which they were founded have been advanced to a generic or subgeneric designation; namely, the group *Læves*, de Koninck, which included *P. Leonhardi* = *Koninckina*; the *Proboscidei*, de Koninck, for shells like *P. proboscideus*, de Verneuil, a group for which ŒHLERT has proposed the subgeneric term PROBOSCIDELLA; and the *Caperati*, de Verneuil, a group of Devonian and Carboniferous forms essentially equivalent to PRODUCTELLA. WAAGEN has proposed to divide the group *Striati*, de Verneuil, into the *Lineati* and *Irregulares*.

We have then the following arrangement, with citations of American representatives of each group:

I. *Lineati*, Waagen. Surface covered with fine radiating costæ which are rarely spinous and are not crossed by concentric plications or wrinkles. These shells are greatly produced and sometimes the anterior margins of the valves are modified by the development of a fold or sinus (*P. Americanus*, Swallow, = ? *P. æquiradiata*, Shumard). The shells were very fragile and have usually been subjected to much distortion in fossilization.

Examples:

P. Cora, d'Orbigny.
P. Prattenanus, Norwood.
P. lævicostus, White.
P. ovatus, Hall.
P. Americanus, Swallow.
P. æquicostatus, Shumard.
P. pileiformis, Newberry.
P. nodosus, Newberry.

II. *Irregulares*, Waagen. Elongate shells very narrow at the beak, mytiliform in outline; mode of growth quite irregular. Surface as in the *Lineati*; spines grouped almost wholly about the cardinal line.

We are not aware that any member of this group has been recognized in America. The best known species is *P. striatus*, Fischer, a widely distributed form in the Carboniferous limestone of Europe. WAAGEN has described the species *P. compressus* and *P. mytiloides*, from the Permo-Carboniferous of the Salt-Range.

III. *Semireticulati*, de Verneuil. The longitudinal ribs are sparsely spinous; surface of the visceral disc covered with concentric wrinkles.

This group includes the greater number of North American species, but it

is to be observed that specific distinctions in the group are established with great difficulty on account of the persistence of the type of structure without essential modification.

Examples:

P. semireticulatus, Martin.
P. arcuatus, Hall.
P. costatus, Sowerby.
P. Burlingtonensis, Hall.
P. Altonensis, Norwood and Pratten.
P. Chesterensis, Worthen.
P. Wortheni, Hall.
P. magnus, Meek and Worthen.
P. nanus, Meek and Worthen.
P. Lasallensis, Worthen.
P. tenuicostatus, Hall.

IV. *Spinosi*, de Verneuil. Surface strongly tuberculose or spinose; not reticulated.

Examples:

P. Nebrascensis, Owen.
P. asper, McChesney.
P. scabriculus, Martin.
P. marginicinctus, Prout.

V. *Fimbriati*, de Koninck. Surface without radiate striæ or ribs; covered with concentric ridges or plications, bearing rows of small, thickly set spines.

Examples:

P. punctatus, Martin.
P. vittatus, Hall.
P. biseriatus, Hall.
P. alternatus, Norwood and Pratten.
P. symmetricus, McChesney.
P. Rogersi, Norwood and Pratten.

VI. *Horridi*, de Verneuil. Surface without radiating or concentric plications; pedicle-valve with a deep sinus. It is doubtful if any member of this group is known from American faunas. Among European species are:

P. horridus, Sowerby.
P. Geinitzianus, de Koninck.
P. opuntia, Waagen.

VII. *Mesolobi*, de Koninck. Surface without radiating plications, except a prominent median rib. Unknown in this country.

Examples in the European Devonian are:

P. mesolobus, Phillips.
P. Christiani, de Koninck.

GENUS PRODUCTELLA, HALL. 1847.

PLATE XVII, FIGS. 1-9, 16-46.

Productus (*partim*) of earlier authors.
1840. *Leptæna*, J. DE C. SOWERBY. Trans. Geol. Society London, vol. v, p. 704, pl. lvi, fig. 5.
1840. *Productus* (*partim*), MURCHISON. Bull. Societé Geol. de France, vol. xi, p. 255.
1842. *Strophomena*, VANUXEM. Geol. N. Y. Rep. Third Dist., p. 179.
1842. *Strophomena*, CONRAD. Journ. Acad. Nat. Sci. Phila., vol. viii, p. 256, pl. xiv, fig. 9.
1846. *Strophalosia* (*partim*), KING. Ann. and Mag. Nat. Hist., vol. xviii.
1854. *Productus*, NORWOOD and PRATTEN. Jour. Acad. Nat. Sci. Phila., vol. iii, p. 21.
1857. *Productus*, HALL. Tenth Rept. N. Y. State Cab. Nat. Hist., pp. 172-180.
1858. *Productus*, HALL Geol. Surv. Iowa, vol. i, part 2, pp. 498-500, 517, 518, pl. iii, figs. 8-10; pl. vii, figs. 1, 3, 4.
1860. *Productus*, SWALLOW. Trans. St. Louis Acad. Sci., vol. i, p. 640.
1861. *Productus*, HALL. Fourteenth Rept. N. Y. State Cab. Nat. Hist., p. 99.
1862. *Producta*, A. WINCHELL. Proc. Acad. Nat. Sci. Phil., vol. xiv, p. 411.
1863. *Producta*, A. WINCHELL. Ibidem, vol. xv, p. 4.
1865. *Producta*, A. WINCHELL. Ibidem, vol. xvii, p. 114.
1867. *Productella*, HALL. Palæontology N. Y., vol. iv, pp. 153-160, 162-184, pl. xxiii, figs. 1-11, 25-49; pls. xxiv, xxv and xxvi.
1867. *Productella*, HALL. Twentieth Rept. N. Y. State Cab. Nat. Hist., p. 245.
1868. *Productus*, MEEK and WORTHEN. Geol. Surv. Illinois, vol. iii, p. 412, pl. x, fig. 3.
1870. *Productus*, A. WINCHELL. Proc. American Philos. Soc., vol. xii, p. 249.
1872. *Productus* (*Productella*), HALL and WHITFIELD. Twenty-fourth Rept. N. Y. State Mus. Nat. Hist., p. 198.
1874. *Productella*, NICHOLSON. Geological Magazine, n. s., vol. i, p. 118.
1875. *Productus* (*Productella*), HALL and WHITFIELD. Twenty-seventh Rept. N. Y. State Mus. Nat. Hist., explanation pl. ix, figs. 9, 10.
1877. *Productus*, MEEK. U. S. Geol. Expl. 40th Parallel, p. 36, pl. iii, fig. 7.
1879. *Productella*, RATHBUN. Proc. Bost. Soc. Nat. Hist., vol. xx, p. 17.
1883. *Productella*, HALL. Rept. N. Y. State Geol. for 1882, pl. (xvii) 48, figs. 1-9, 16-46.
1884. *Productus* (*Productella*), WALCOTT. Pal. Eureka Dist., pp. 128-133, 214, pl. ii, fig. 10; pl. vii, fig. 2; pl. xiii, figs. 8, 9, 18-20.
1888. *Productus*, HERRICK. Bull. Denison Univ., vol. iii, pp. 31-34, pl. iii, figs. 18, 28; pl. vi, fig. 16; pl. vii, fig. 18.
1889. *Productella*, NETTELROTH. Kentucky Fossil Shells, pp. 69, 70, pl. xvii, figs. 5-9; pl. xxvi, fig. 7.

It is a natural presumption that the earlier forms organized on the productoid type of structure should retain the cardinal areas and articular processes of the valves, and it is upon the natural persistence of these features in many if not all of the Devonian species that the genus PRODUCTELLA was based. This group was founded on the *Productus subaculeatus*, Murchison,* a middle

* This species was identified by M. DE VERNEUIL as occurring in the American Devonian rocks near Charleston Landing, Indiana, and the fossil originally figured, as typical PRODUCTELLA, was obtained from near Jefferson, in what was then regarded as the Corniferous limestone, but which later investigations have proved to be the calcareous beds representing the Hamilton group in its western extension. See Pal. N. Y., Vol. V, pt. ii, p. 139; "Note on the Hydraulic Beds and Associated Limestones at the Falls of the Ohio."

Devonian form, and, as already observed, it is essentially equivalent to DE VERNEUIL's division of the *Producti caperati;* certain small species which extend into the earlier faunas of the Carboniferous still retaining the cardinal area and teeth. It is to be noticed that these features are in all cases obscure and frequently difficult to discern, but even the large species occurring in the late Devonian (Chemung) and early Carboniferous (Waverly), and which resemble more in size and expression the normal species of the later faunas, do retain them. There is no reliable evidence that PRODUCTUS, as we have used the term, occurs in Devonian faunas, and there is little reason to doubt that, in this country, it does appear as early as the Waverly group (*P. Newberryi* and *P. semireticulatus*).

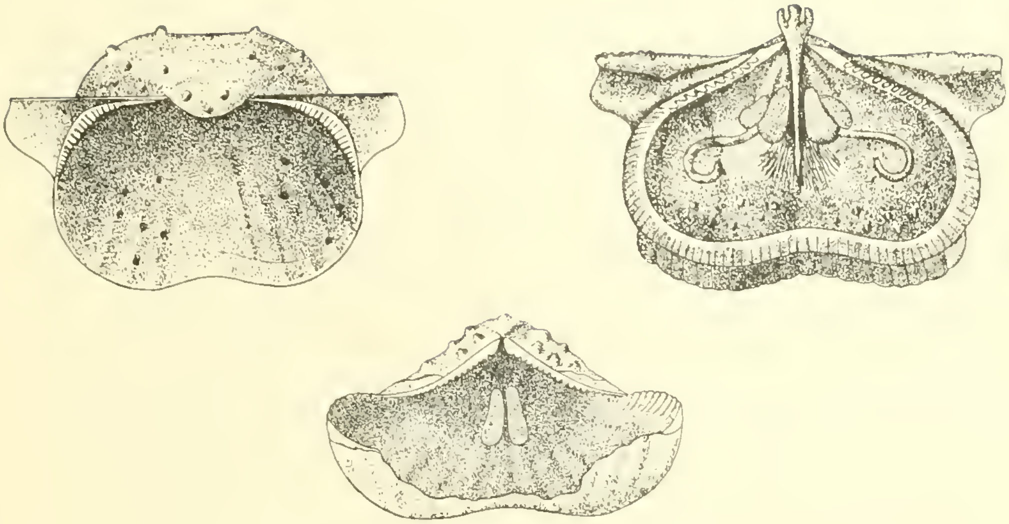
There are some peculiarities in PRODUCTELLA which may prove of value in classification. The cardinal process rarely shows a trilobation when viewed from the posterior face, the bilobate character being about equally developed on both sides; the delthyrium is apparently covered on both valves; the muscular impressions of the brachial valve are very small, and their surface is not dendritic: the brachial ridges or reniform impressions are rarely retained, if ever present. The existence of teeth in the pedicle-valve implies the presence of sockets and crural plates in the brachial valve. The latter are divergent ridges nearly parallel to the hinge-line, and corresponding to the thickened ridges lying just within the cardinal margin in most species of PRODUCTUS. The combination of all these features, though they may not be sufficient to give to PRODUCTELLA a thoroughly valid biological basis as a strongly marked and distinctly limited generic form, may nevertheless serve to continue the usefulness of the designation in distinguishing certain forms among the barren mass of Productoid material, where individuality is feebly represented, or entirely lost in the multitude of forms. With our present knowledge and views of classification it must be regarded that PRODUCTELLA and PRODUCTUS are members of a descending series and represent different stages in the process of degeneration. In the discussion of the characters of PRODUCTELLA, given in Volume IV of the Palæontology of New York (p. 151), the following observation was made: "It appears to me that we have in the De-

vonian period the incipient manifestation of the productidian type, which became modified in the later Carboniferous period, where, with conditions favorable to its excessive development, it has assumed extravagant forms and proportions, but here and there indicating the character of its prototype in the presence of an area and foramen, among species of a genus which is characterized by the absence of these features. In the still later Permian period, with changed conditions, we have an approximate return to the earliest forms of the species, or to the prototype; and in reality the foundation of the genus lies in the Devonian forms which have been referred to STROPHALOSIA."

From the Carboniferous *Producti* Dr. WAAGEN proposed in 1884 to separate a group characterized by a prominent internal ridge situated just within the margins of the valves. To this group he gave the designation MARGINIFERA, and described it in the following terms:

"The shells which I consider as belonging to the present genus are always rather small, and never attain any considerable dimensions. In their external appearance they are absolutely like *Productus*, so long as the shell is not broken, but as soon as the shell-margin is removed, which very easily happens, the difference comes to light. The cause why the shell-margin so very easily breaks off is a thick, prominent shelly ridge, placed vertically on the internal surface of the dorsal valve, and by which the visceral part of that valve is girt. In the ventral valve a similar ridge is developed within the wings only. In this way the visceral part of the shell is perfectly chambered off from the remainder of the shell. These prominent concentric ridges are sometimes finely striated and crenulated; sometimes smooth. The other internal characters are in all the specimens at my disposal (except in *Marg. typica*, W., where the description will be found) very indistinct, but on the whole they seem to be similar to those of *Productus*.

"This strange chambering off of the visceral part by means of proper projecting ridges seems to me perfectly sufficient for the generic distinction of these forms. Certainly it is as well worthy of notice as the existence of an area in *Aulosteges* or the like." (Salt-Range Fossils, p. 713.)



FIGS. 28-30. *Marginifera typica*, Waagen.
After WAAGEN.

The peculiar features described may perhaps be valid ground for the proposed subdivision when in their extreme development, as in *M. typica* and *M. ornata*, Waagen (see figures in the work cited, plates lxxvi and lxxvii), but an examination of extensive collections shows that these elements appear, in various stages of development, in different species, from the middle Devonian upward through the Coal Measures. In all the American species examined, the characters on which this division is founded seem to be rather in an inceptive condition when compared with *Marginifera typica*, and can scarcely be considered as of such organic importance as to warrant the generic separation of such forms, especially when it will involve a considerable number of species in which the articulating apparatus and all the more essential characteristics correspond with PRODUCTUS. Unless applied in a very restricted sense, this term can scarcely be adopted to designate an altogether reliable separation from PRODUCTUS, for it is manifest that many species, possessing incipient internal characters which show them to be in the line of development toward MARGINIFERA can not, on such grounds, be separated from the old genus, while the number of forms in which these characters described become fixed and highly developed, are very few.

Dr. Waagen has taken Norwood and Pratten's species, *Productus splendens*, as the type of the group which embraces his typical species, and further has expressed the opinion that the American species from the Coal Measures belong for the greater part to Marginifera. It is extremely doubtful if the evidence will sustain this assumption though there are certain species of the Coal Measures, *Productus splendens*, Norwood and Pratten, *P. longispinus*, Sowerby, *P. Lasallensis*, Worthen, which show the characters of Marginifera in some stage of development.

In the species *Productus dissimilis*, Hall,* from the middle Devonian of Rockford, Iowa, and the upper Devonian of New York, similar internal characters are quite strongly developed, especially in the pedicle-valve, and in both valves the margins of the ridges are more or less distinctly crenulated. While the species has the cardinal area, teeth and sockets in an exceedingly obscure condition, the cardinal process is like that of Productella, strongly bifurcated to its base, and its external surface presents characters rarely met with either in Productus or Productella, but not uncommon in Strophalosia; a spiniferous pedicle-valve, and a brachial valve without spines, but covered with concentric lamellose ridges.

* Mr. Walcott has proposed to change the name of this species to *P. Hallana* (Monograph U. S. Geol. Surv., vol. viii, p. 130, 1884), as de Koninck had used the same term for a Devonian species which is evidently a Productella. Should, however, the American species be referred to Marginifera, its original designation may be retained.

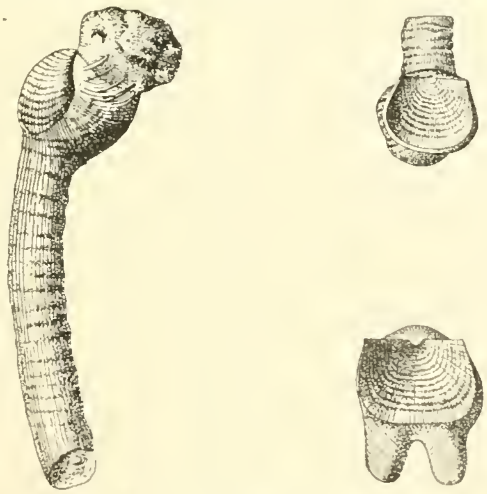
GENUS PROBOSCIDELLA, ŒHLERT. 1887.

1840. *Productus*, DE VERNEUIL. Bull. Soc. Géol. de France, vol. vi, p. 259, pl. iii, fig. 3.
1841. *Clavagella*, GOLDFUSS. Petrefacta Germaniæ, vol. ii, p. 285, pl. clx, fig. 17.
1841. *Productus*, VON BUCH. Abhandl. der Königl. Akad. der Wissensch. zu Berlin, Theil i, p. 40.
1843. *Productus*, DE KONINCK. Descript. Animaux Fossiles du Terr. Carb. de Belgique, p. 11, fig. 4.
1847. *Productus*, DE KONINCK. Monographie du genre Productus, p. 62, pl. vi, fig. 4.
1854. *Productus*, NORWOOD and PRATTEN. Journ. Acad. Nat. Sci. Philadelphia, 2d Ser., vol. iii, p. 10.
1861. *Productus*, DAVIDSON. British Carb. Brachiopoda, p. 163, pl xxxiii, figs. 1-4.
1880. *Productus*, DAVIDSON. British Carb. Brachiopoda, Suppl., p. 311, pl. xxxvi, fig. 13.
1887. *Proboscidella*, ŒHLERT. In FISCHER'S Manuel de Conchyliologie; Brachiopodes, p. 1277.

DIAGNOSIS. "Valves very unequal; the dorsal small, concave, operculiform; the ventral larger, convex, furnished with two lateral expansions which bend downward to meet the margins of the dorsal valve, and an anterior expansion which is produced forward into a long cylindrical tube, sometimes attaining twice the length of the shell; the suture appears on the dorsal side in the median line. Sometimes instead of a single tube there is a double enrollment resulting in two distinct tubes. The surface is ornamented by concentric plications, traversed by fine radiating ribs, which are flexuous and close together; the last plication, and the groove accompanying it, is sharper than the others and marks the separation of the ventral valve, properly speaking, from its lateral and anterior expansions upon which the concentric markings are rare, faintly developed or wholly wanting, while the radiating striæ are regularly continued." (ŒHLERT, *loc. cit.*)

Carboniferous limestone.

Type. *Productus proboscideus*, de Verneuil.



FIGS. 31-33. *Productus* (*Proboscidella*) *proboscideus*, de Verneuil. After DE KONINCK.

OBSERVATIONS. This term has been proposed for the species above mentioned, in which the development of the shell is of such an extravagant character as to have necessarily modified the functions and anatomy of the animal. Though the internal markings of this species have not been described, it is probable that they will prove not to vary materially from those of PRODUCTUS, and even the external features are but a result attained along a line of development represented in such forms as *P. striatus*, Fischer, *P. ermineus*, de Koninck, *P. genuinus*, Kutorga, and not resting with *P. proboscideus*, but attaining an extreme in DE KONINCK's species, *P. Nystianus*, in which the pedicle-valve is developed into two tubes, one on the frontal and one on the cardinal margin.* DE KONINCK has shown that in this last-named species the formation of these tubes is an accompaniment of decrepitude, and that the early stages of the shell conform to the normal form of PRODUCTUS. No thoroughly satisfactory explanation of the function of these enrollments of the shell has been offered. DE KONINCK was disposed to regard them as passages for muscular fibers by which the animal was attached and D'ORBIGNY considered them as malformations. The former view requires too radical a modification of the internal anatomy, and, as to the latter, there can be no doubt that these tubes which are constant, though variable in form, size and even in number, are altogether normal. The further suggestion of D'ORBIGNY that the animal, from its constrained position, possibly buried in the sediments, was forced to prolong its shell so as to reach the surface of the sea-bottom, seems reasonable, and met with the endorsement of Mr. DAVIDSON.

The group is probably represented in American faunas by the imperfectly known *P. clavus*, Norwood and Pratten, from the Carboniferous of Illinois, a form which seems to be a close ally of the *P. proboscideus* of Visé and Yorkshire.

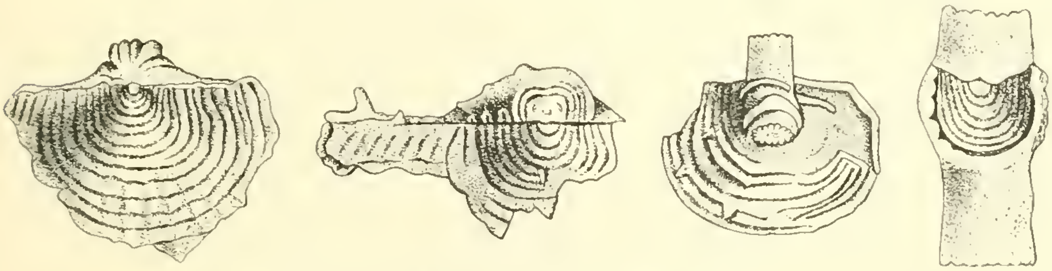
* See DE KONINCK's figures of all these species; Monogr. genre Productus, pls. i, vi, xiv.

GENUS ETHERIDGINA, ŒHLERT. 1887.

1876. *Productus*, ETHERIDGE, JR. Quart. Journ. Geol. Society, vol. xxxii, p. 454, pl. xxiv, figs. 1–14; pl. xxv, figs. 15–24.
1878. *Productus*, ETHERIDGE, JR. Quart. Journ. Geol. Society, vol. xxxiv, p. 498.
1880. *Productus*, DAVIDSON. Monogr. British Carb. Brach. Suppl., p. 303, pl. xxxv, figs. 4–13.
1887. *Etheridgina*, ŒHLERT. In FISCHER'S Manuel de Conchyliologie; Brachiopodes, p. 1278.

DIAGNOSIS. "Shell of very small size, nearly as broad as long, attached to foreign bodies by the spines of the ventral valve; cardinal line straight, nearly equaling the greatest width of the shell; pallial outline semicircular; ventral valve with a small, entire [?] beak; surface ornamented by concentric flexuous plications, bearing a few scattered spines: cardinal process quadrifid."—ŒHLERT, *ut. cit.*

Type, *Productus complectens*, Etheridge, Jr.



FIGS. 34–37. *Productus* (*Etheridgina*) *complectens*, Etheridge. After ETHERIDGE.

OBSERVATIONS. This shell was admirably described by Mr. ETHERIDGE in his paper on "An Adherent Form of Productus" (1876) and presents the interesting combination of distinctive productoid characters (absence of cardinal area, hinge, etc.), with a mode of growth characterizing the genus STROPHALOSIA. The very small shells of this genus, which is thus far represented by the type species only, have been found adhering to crinoid columns and fragments of bryozoa; that is, to surfaces of little expansion; hence the creeping spines appear to effect an attachment by encircling or hugging their host. This appearance is somewhat deceptive; the surface of the pedicle-valve is itself adherent, and the mode of growth of both shell and spines the same as that already observed in some of the small species of STROPHALOSIA (*S. radicans*,

S. scintilla, *S. Keokuk*) which have usually been found attached to flatter surfaces.

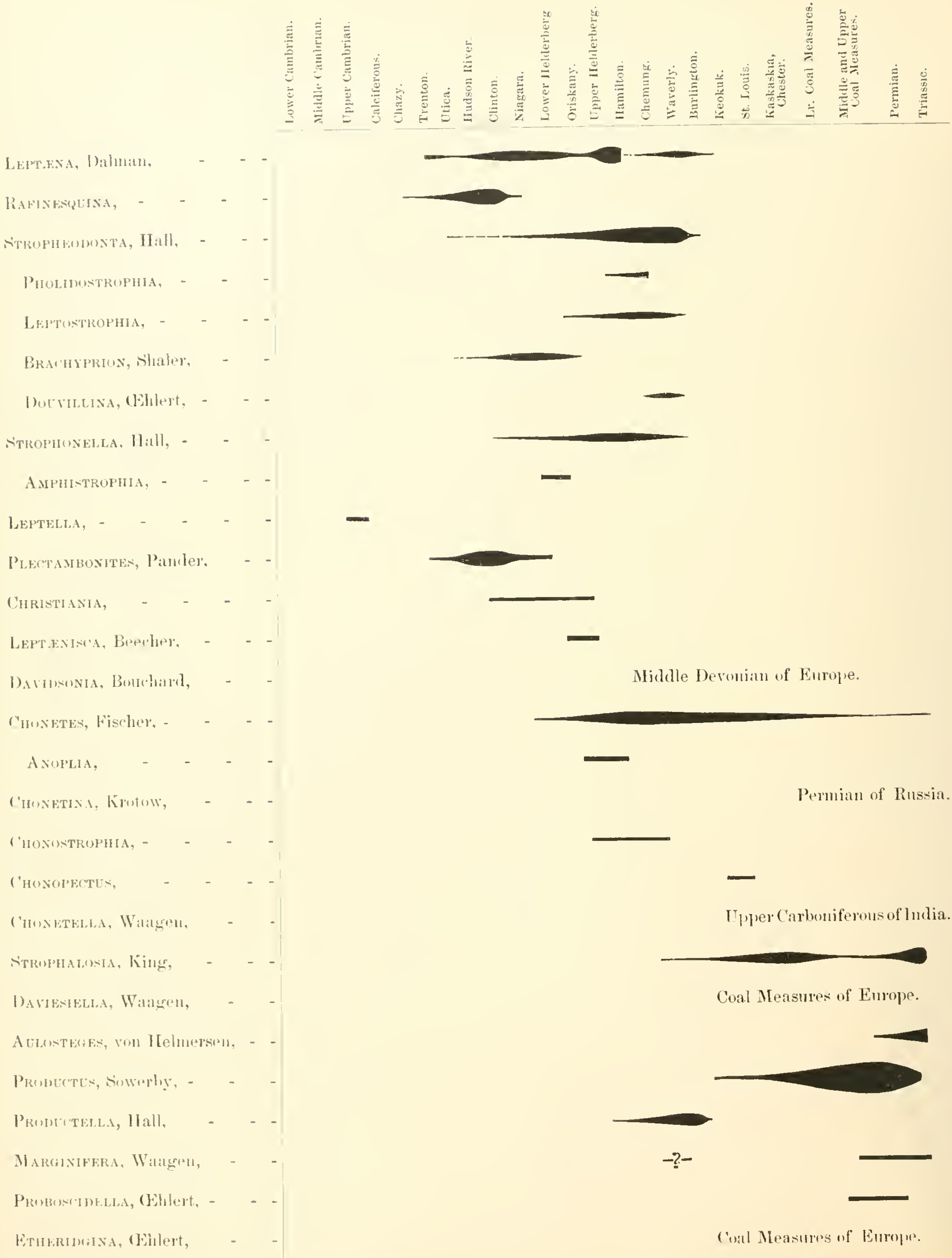
Mr. ETHERIDGE makes the following interesting observations on these fossils:

"When the organism to which the PRODUCTUS is attached is of larger size than the latter, the whole of the ventral valve is applied to it, the spines spreading out and around on each side; but when the foreign body is of less diameter than the PRODUCTUS, as is usually the case with fragments of Polyzoa, several of the spines are wound tightly round, especially near the beak, and the remainder of the valve remains free. Attachment took place during the life of the Crinoid; for in nearly every case where the PRODUCTUS remains adhering, we find that its rate of growth was less than that of the Crinoid, the result being that the substance of the latter surrounded or enclosed its parasite, first the encircling spines disappearing and gradually the shell. We have specimens showing this remarkably well in all stages of the process, from the mere absorption of the spines by the substance of the Crinoid, up to the total disappearance of the PRODUCTUS itself, when the Crinoid stem assumes a swollen or distorted appearance. From a consideration of this gradual absorption by the Crinoid stem there arise two questions: Did the PRODUCTUS when once attached lose the power to free itself? or, Did the absorption by the Crinoid, contrary to the view indicated previously, commence only after the death of the PRODUCTUS?"

Some of Mr. ETHERIDGE's figures of this species, which is from the Lower Carboniferous limestone of Edinburghshire, Scotland, are here reproduced.

BRACHIOPODA.

The tabular arrangement is intended to show the geological range of these genera, so far as known at the present time. The material accessible for the study of the older groups (except SCENIDIUM) is too meagre to afford ground for generalization.



Lower Cambrian.
Middle Cambrian.
Upper Cambrian.
Calciferous.
Chazy.
Trenton.
Utica.
Hudson River.
Clinton.
Niagara.
Lower Helderberg.
Oriskany.
Upper Helderberg.
Hamilton.
Chemung.
Waverly.
Burlington.
Keokuk.
St. Louis.
Kaskaskia, Chester.
Lr. Coal Measures.
Middle and Upper Coal Measures.
Permian.
Triassic.
Leptæna, Dalman,
Rafinesquina,
Stropheodonta, Hall,
Pholidostrophia,
Leptostrophia,
Brachyprion, Shaler,
Douvillina, Œhlert,
Strophonella, Hall,
Amphistrophia,
Leptella,
Plectambonites, Pander,
Christiania,
Leptænisca, Beecher,
Davidsonia, Bouchard,
Middle Devonian of Europe.
Chonetes, Fischer,
Anoplia,
Chonetina, Krotow,
Permian of Russia.
Chonostrophia,
Chonopectus,
Chonetella, Waagen,
Upper Carboniferous of India.
Strophalosia, King,
Daviesiella, Waagen,
Coal Measures of Europe.
Aulosteges, von Helmersen,
Productus, Sowerby,
Productella, Hall,
Marginifera, Waagen,
?
Proboscidella, Œhlert,
Etheridgina, Œhlert,
Coal Measures of Europe.

SUPPLEMENTARY NOTE ON THE GENUS OBOLUS, VON EICHWALD.

The preceding discussions of the inarticulate genera (ending on page 184) were received from the printer in March, 1890. Since that date an important contribution to our knowledge of the genus Obolus has been made by A. Mickwitz,* whose studies are based upon finely preserved material from Joafall, near Jegelecht, Esthonia.

Students of the brachiopoda will appreciate the author's statement that "this genus, notwithstanding the exceeding abundance of its shells in the upper layers of the Ungulitensandstein of our Cambrian formation, from Baltischport to the banks of the Sjas, and in spite of its early discovery, has been hitherto as good as unknown." The details of the internal structure of both valves are worked out with such a degree of elaboration, that we can do no less than give in this place the author's diagnosis of the genus and copies of his accompanying illustrations, observing that the genera Aulonotreta, Kutorga, and Schmidtia, Volborth, are here regarded as synonymous with Obolus :

"Shell nearly equivalve, equilateral, depressed or slightly convex; outline circular or somewhat elongate longitudinally or transversely, in some species subtriangular or elongate-quadrate.

"Shell-substance calcareo-corneous, structure laminated; surface lustrous, with concentric and radial striae varying to deeply incised transverse folds and radial ribs. Color of the shell dark greyish-blue to black; when in process of decomposition, whitish to dark brown-red. Anterior and lateral margins thin, sharply angled and fragile, lying in the plane of the greatly thickened cardinal margin. The cardinal area lies in the plane of the margins, in the larger valve being somewhat triangular on account of the elevation of the beak, and divided equally by the pedicle-groove; in the smaller valve rounded at the apex, and in both striated parallel to the base, and grooved from apex to base by the

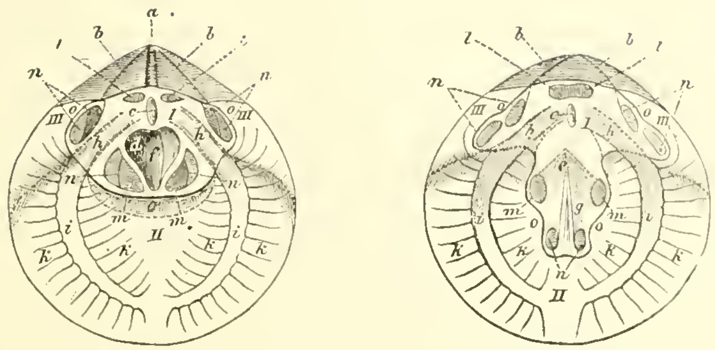
* Vorläufige Mittheilung über das genus Obolus, Eichwald: Mélanges geologiques et paléontologiques tirés du Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg. Tome I. (Read October 9th, 1890.)

more or less divergent marks of the impressions of the lateral sliding muscles. The middle portion of the thickened margin slopes to the center of the shell, forming in the larger valve a line concave as to the beak, and in the smaller valve a sinus. The lateral portions of the thickened area merge gradually into the thin margins of the valves. Beneath the hinge-line in both valves is a narrow median septum, fainter in the small valve, and in both a scarcely visible ridge discernible only in oblique light. On either side of the septum begins a furrow which increases in depth and passes through the thickened area in a line parallel to the margins of the shell.

"The impressions of the vascular trunks of the mantle are continued from these furrows into the anterior portions of the valves and parallel to their margins. Secondary vascular sinuses radiate in great numbers from the main trunks toward the margins and center of the shell.

"In the median line of the larger valve, between the median septum and the anterior margin of the thickened cardinal region, lies a deep cordate pit, having its apex directed toward the anterior margin of the shell and with a shallow median furrow. In the sinus of the smaller valve is a faint median swelling, extending beyond the center of the shell and divided longitudinally by an obscure groove.

"Muscular impressions in five pairs for each valve; two of the adductors and three of the sliding muscles. The impressions of the adductors lying directly beneath the cardinal margin, are separated in the larger valve and in juxtaposition in the smaller. The anterior pair in the larger valve lies on either side of the cordate pit, in the smaller at the apex of the corneous callosity, extending into the middle of the valve and forming the sinus. Of the sliding muscles there is a pair on each side of both valves, close to the cardinal margin and between the lateral furrows and the margins of the shell. In the larger valve these scars are in juxtaposition, but in the smaller they are further apart, touching only at their extremities. The third pair of these impressions in the larger valve lies close against, but outside the anterior adductors; in the smaller valve on either side of the anterior extremity of the median swelling, in the sinus, and nearer together than the scars of the anterior adductors. The scars of the *paries* passes closely about the muscular impressions, crossing both lateral furrows and terminating in the central portion of the cardinal margin."



Larger valve. Smaller valve.

FIGS. 38, 39. Diagrammatic view of *Obolus Quenstedti*. After MICKWITZ.

a, Pedicle-groove; *b*, impression left by the advance of the lateral sliding muscles; *c*, median septum; *d*, cordate pit; *e*, sinus; *f*, median groove; *g*, median swelling; *h*, lateral grooves; *i*, impressions of vascular trunks; *k*, impressions of secondary sinuses; *l*, impressions of posterior adductors; *m*, impression of anterior adductors; *n*, impressions of sliding muscles; *o*, outline of splanchnocœle; I, splanchnocœle; II, brachiocœle; III, pleurocœle.

According to this diagnosis, the analogies of OBOLUS, with LINGULA are at once striking, though there are important differences. In *L. anatina* there are four pairs of lateral or sliding muscles, while there appear to be but three in *Obolus Quenstedti*; according to MICKWITZ the anologue of *k* (middle lateral in LINGULA, see figure on page 10), being absent in the latter. The adductors are the same in number in both, though there is considerable difference in their disposition; the position of the posterior band, which is divided at its ventral insertion being the same as that of the great umbonal in LINGULA. In LINGULA, again, KING has shown that one of the transmedian bands is divided, which does not appear to be true of *Obolus Quenstedti.*

It must be observed that these results have not been obtained from the type-species of the genus, *Obolus Apollinis*, von Eichwald, but from a hitherto undescribed form. Experience has taught us that the greatest care is required in the discrimination of generic values among the oboloid genera of the early palæozoic faunas, and it may be a question for subsequent determination whether a species showing so many important differences from the structure hitherto known in *O. Apollinis* should be regarded as congeneric with it. Attention is called to the similarity in many points of structure of *O. Quenstedti* with the genus OBOLELLA, Billings, as shown in the figures on Plate II of this volume.

DESCRIPTIONS OF NEW SPECIES FIGURED IN THIS VOLUME.

ORTHIS ? SAFFORDI, sp. nov.

PLATE V A, FIGS. 38–40.

SHELL semielliptical in outline; valves subequally convex, the pedicle-valve being the more elevated at the apex. Hinge-line long and straight, giving the shell a strophomenoid appearance. Cardinal area low; delthyrium uncovered.

Surface covered with numerous rounded, sharply elevated striæ, increasing by intercalation, and crossed by exceedingly fine concentric lines. The details of the interior are not known, but the relations of the shell to ORTHIS are demonstrated by the open delthyrium and simple cardinal process, slightly lobate on its posterior face.

Length of the type specimen, 17 mm.; width along the hinge, 22 mm.

Trenton horizon. *East Tennessee.*

ORTHIS ? HOLSTONI, SAFFORD.

PLATE V A, FIGS. 35–37.

SHELL transverse; outline semicircular. Hinge-line long and straight. Pedicle-valve with a high, vertical, cardinal area, transected by a very broad, uncovered delthyrium; beak not incurved; surface sloping evenly toward the margins, slightly rounded in the median line, and faintly depressed toward the cardinal angles. Brachial valve depressed convex, nearly flat, with a broad and low median sinus.

Surface of both valves covered with fine, elevated, radiating striæ, crossed by faint, concentric, cancellating lines which have a slight retral bend on the striæ.

This shell has very much the aspect of a CLITAMBONITES, but of the two specimens examined, neither has evidence of a deltidium, and a trans-

verse section across the umbo of one, shows that the dental lamellæ, though strong and convergent, did not unite to form a spondylium. Received from Professor SAFFORD.

Trenton horizon (Glade limestone). *Near Nashville, Tennessee.*

ORTHIS (PLÆSIOMYS) LORICULA, sp. nov.

PLATE V A, FIGS 32–34.

SHELL strophomenoid in outline; reversed convex. Hinge-line long and straight making the greatest diameter of the shell. Cardinal areas narrow, subequal. In the pedicle-valve the delthyrium is covered by a convex plate extending for one-half its length; the area is erect, the beak not prominent. The valve is slightly convex in the umbonal region but is depressed outward in all directions, most strongly in the median line. The brachial valve is depressed about the beak, convex over the pallial region and divided in the median line by a shallow sinus. The interior characters of the valves are essentially the same as those in *Orthis subquadrata.*

External surface covered with numerous fine, elevated striæ, alternating in size and crossed by finer concentric lines.

Length of an average specimen, 18 mm.; width, 21 mm.

Trenton horizon. *Fountain, Minnesota.*

ORTHIS (DALMANELLA) ARCUARIA, sp. nov.

PLATE V C, FIGS. 20, 21.

SHELL with a general similarity to that of *Orthis elegantula*, Dalman, but having the marginal outline more circular, the pedicle-valve more evenly convex, the umbo more prolate, and the brachial valve considerably more convex. The pedicle-valve bears a broad fold, and the brachial a shallow sinus, in the median line. In the interior of the pedicle-valve the muscular area is elongate and very deeply impressed, the umbonal portion of this valve being considerably thickened.

Surface covered with numerous very fine radiating striæ.

Length of the type specimen, 19 mm.; width, 18 mm.; depth, 9 mm.

Hudson River group. *East Tennessee.*

ORTHIS (DALMANELLA) SUPERSTES, sp. nov.

PLATE V C, FIGS. 44-47.

SHELL of small size and having the general form and expression of *O. hybrida* Sowerby. Hinge-line short, beaks but slightly elevated. Marginal outline varying from subquadrate to subcircular. Valves about equally convex. In the pedicle-valve the beak is somewhat inflated and slopes evenly in all directions for nearly one-half of the shell; from this point onward is a broad, low median sinus, which is most conspicuously developed in old and gibbous shells. In rare instances there is a low elevation in the bottom of this sinus The opposite valve also bears a median sinus which takes its origin at the beak. In the interior of the pedicle-valve the muscular area is sharply defined, subquadrate in outline, the adductor scars small and the diductors well developed. In the brachial valve the cardinal process and crural plates are prominent; the muscular area well defined and quadruplicate.

The external surface of the valves is covered with fine, elevated striæ, of which twenty of the coarsest reach the beak; this number increasing by intercalation to about fifty at the margin. Near the margin very fine concentric striæ are visible.

Length of a normal individual, 12 mm.; width, 13 mm.; depth, 9 mm.

Chemung group. *Near Howard, Steuben county, N. Y.*

ORTHIS (RHIPIDOMELLA) OWENI, sp. nov.

PLATE VI, FIGS. 19-21.

SHELL having somewhat the outline of *O. Vanuxemi*, but more elongate transversely and gently sinuate or emarginate on the anterior edge. The shells are usually flattened, but where the form is retained the pedicle-valve shows a hinge-line whose length is somewhat less than one-half the transverse

diameter of the shell. The beak is acute, the umbo full but not conspicuous. Along the center of the valve is a broad, low sinus, frequently very inconspicuous. The interior of this valve is characterized by the relatively small area covered by the muscular scars, a feature in which it resembles *O. Peloris* of the Schoharie grit. The pallial region is pitted or covered with faint, closely anastomosing ridges. On the brachial valve the median sinus begins at the apex and becomes very pronounced as it widens anteriorly. From the ridges forming its lateral margins the surface slopes rather abruptly and without much curvature. On the interior the cardinal process and crural plates are not prominently elevated; the muscular area is small, quadripartite, the lateral pairs of scars being separated by a broad, thick ridge.

Surface of both valves covered by a great number of fine radiating, hollow striæ, from 110 to 130 in number, which are crenulated by minute concentric lines and crossed at intervals by coarser lines of growth. The surface was originally covered with short spinules, which are rarely preserved. This shell has heretofore been commonly referred to *Orthis Michelini*, Léveille.

Keoknk group (Knobstone formation). *Button-mould Knobs, Kentucky.*

ORTHIS (SCHIZOPHORIA) SENECTA, sp. nov.

PLATE VI A, FIGS. 23, 24

SHELL subquadrate or transversely elliptical, resupinate, unequally biconvex. The pedicle-valve is depressed convex in the umbonal region and develops a broad, low median sinus toward the anterior margin. The brachial valve is the more convex and slopes evenly toward the lateral margins, the median region being rendered slightly more prominent by an obscure fold.

Internal markings as in other members of SCHIZOPHORIA.

External surface covered with fine, subequal, closely covered radiating striæ.

Length of a typical example, 17 mm.; width, 21 mm.

Clinton group. *Reynale's Basin, Niagara county, New York.*

STROPHOMENA CONRADI, sp. nov.

PLATE IX A, FIG. 3; AND PLATE XX, FIGS. 32, 33.

SHELL semiovate in outline; hinge-line straight and forming the greatest diameter of the shell. Cardinal area narrow on both valves; broader on the pedicle-valve and but slightly elevated at the umbo. Delthyrium covered; deltidium perforated at the apex. Pedicle-valve convex in the umbonal region, but becoming deeply depressed and concave over the middle of the shell and again elevated about the margins. The depression of the valve is most conspicuous along the median line and on the anterior margin where it produces a subnasute extension. The brachial valve is flat or slightly concave at the umbo, becoming convex over the pallial region; it reaches its greatest convexity at about the middle of the shell and is thence deflected gradually in the median line and more abruptly on the lateral slopes.

Surface of the shell covered with radiating striæ, arranged in fascicles of 4 to 7 fine ones between each pair of coarser ones There are no concentric rugæ on either valve, but the radiating striæ are crossed by exceedingly minute concentric lines.

Width of the original specimen along the hinge, 23 mm.; greatest length, 19 mm.

Trenton limestone. *Jacksonburg, N. Y.*

STROPHOMENA WINCHELLI, sp. nov.

1883. *Strophomena nutans*, HALL. Rept. State Geologist N. Y. for 1882, expl. pl. (ix) 39, figs. 10, 12-14.

PLATE IX, FIGS. 10, 12-14; PLATE XX, FIG. 26.

SHELL elongate semiovate; strongly convexo-concave. Hinge-line straight and making the greatest diameter of the shell. Cardinal angles sometimes extended. Pedicle-valve with a moderately broad area and deltidium; apex slightly elevated, the valve becoming deeply concave over the pallial region and reflected at the margins. The teeth are strong and divergent, and from their bases extend elevated curving ridges which form the margin of the subcircular or subovate muscular area. Diductor scars broad, enclosing an

elongate and narrow adductor. Within the anterior and lateral margins of the valve is a thickened ridge which is crossed by branches of the vascular sinuses. Brachial valve flat in the umbonal region, very convex over the median portion and sloping gradually to the margins. The cardinal process consists of two slender and short apophyses which are united at their base with the crural plates. The latter are very divergent and extend in a broad curve subparallel to the hinge-line. The muscular scars consist of two pairs, the posterior being broad and striated, the anterior narrow and close to the median line. The members of the pairs are separated by a low median ridge.

Surface of the shell covered with numerous very fine filiform striæ, regularly but not conspicuously alternating in size. Delicate concentric striæ are sometimes discernible.

Trenton horizon. *Clifton and Janesville, Wisconsin.*

This shell has been referred to the *Hemipronites nutans*, James (Meek), of the Hudson River, group which it resembles in its general expression. It differs from that species in its internal characters and more finely and abundantly striated exterior.

Orthothetes desideratus, sp. nov.

PLATE IX A, FIGS. 26, 27.

1883. *Streptorhynchus, sp. ?* Hall. Rept. State Geologist N. Y. for 1882, pl. (xi A) 42, figs. 26, 27.

The original specimens of this species are internal casts of a form with a subcircular marginal outline, very gibbous brachial valve which has its greatest convexity central and slopes evenly to the margins, though with a slight tendency to depression toward the cardinal extremities; a strongly and regularly concave pedicle-valve, elevated at the beak and about the margins. The cardinal area on this valve is moderately high and erect, the hinge-line being slightly shorter than the greatest diameter of the valves. The surface of both valves is covered with numerous fine radiating striæ. The general form and contour of the species is very similar to that of *Orthothetes umbraculum* of the Eifel.

Waverly group. *Medina county, Ohio.*

DERBYA RUGINOSA, sp. nov.

PLATE XIA, FIGS. 25-27.

SHELL subelliptical in outline. Hinge-line short, its length being about two-thirds the greatest diameter of the shell. Pedicle-valve shallow; cardinal area moderately high, its lateral slopes being slightly more than one-half the length of its base; apex scarcely prominent; surface depressed or flat in the umbonal region, becoming irregularly concave anteriorly. Entire valve very irregular in growth, with concentric ridges and furrows. Brachial valve very convex; apex depressed, but the umbonal region gibbous, the greatest convexity being reached at the center of the valve. This valve is also of irregular growth, though the irregularities are not so strongly developed as on the opposite valve. The original specimen is an internal cast in chert to which portions of the inner laminæ of the shell adhere. There are evidences of a flabellate muscular scar on the pedicle-valve and a short ovate muscular area in the brachial valve.

The traces of the surface striæ preserved show them to have been very fine and numerous.

Keokuk limestone. *New Providence, Indiana.*

This species is similar in some general respects to *Derbya Broadheadi*, but differs in its narrower and lower cardinal area, less convex umbo on the brachial valve and in the absence of a median sinus on this valve. It may be compared with the *Streptorhynchus crenistria*, var. *senilis*, Phillips (Davidson), from the lower Carboniferous of Great Britain.

DERBYA? COSTATULA, sp. nov.

PLATE XIB. FIGS. 16, 17.

SHELL small, outline semi-oval. Hinge-line nearly equal to the greatest diameter of the valve. Cardinal area moderately high, with a prominent deltidium very wide at the base. Pedicle-valve with an elevated beak from which the surface slopes to the margins with a tendency to irregular growth. Brachial valve faintly depressed at the umbo, but otherwise pretty regularly convex,

the most elevated point being a little behind the middle of the valve. There is faint median sinus over the anterior region.

Surface marked with a few coarse radial ribs, between each two of which are implanted one, two or three much finer ones. These ribs are crossed by a few distinct concentric varices of growth.

Chester limestone. *Crittenden county, Kentucky.*

This species is readily distinguished by the character of its surface ornamentation, and though the interior features of the shell are as yet unknown, a very closely allied form from the upper Coal Measures near Kansas City has a well developed median septum in the pedicle-valve, and is hence to be referred to the genus Derbya.

Derbya Broadheadi, sp nov.

PLATE XIA, FIGS. 23, 24.

Shell with irregularly suboval marginal outline. Hinge-line short, its length not exceeding, and usually less than one-half the greatest diameter of the valves. Cardinal area of the pedicle-valve high, sometimes regularly triangular, often distorted or somewhat incurved; deltidium broad at the base and rapidly tapering with a faint median groove on its surface. Pedicle-valve convex in the umbonal region, irregularly rugose and depressed over the pallial area. Brachial valve very gibbous at the umbo, the greatest convexity being behind the center of the valve. From the umbonal region the surface slopes evenly toward the lateral and anterior margins, but is more abruptly depressed toward the cardinal extremities where it forms short subalate expansions. The valve is but slightly unsymmetrical and is bilobed by a conspicuous median sinus which takes its origin near the umbo, and widens to the anterior margin.

Surface covered by fine radiating striæ which are of subequal size over the umbonal region, but toward the margin became arranged in fascicles on account of the addition of finer striæ as growth advances. Concentric rugæ and growth-varices are frequent, especially on the pedicle-valve.

Upper Coal Measures. *Near Kansas City, Missouri.*

Derbya Bennetti, sp. nov.

PLATE XIa, FIGS. 34-39.

Shell subtrihedral in general aspect, quite irregular in its growth. Hinge-line short, its extremities on both valves being auriculate. Pedicle-valve much the more irregular in growth, sometimes retaining the scar of attachment at its apex. Cardinal area unusually high, narrow, erect or slightly incurved, and frequently distorted ; delthyrium curved. General surface of the valve depressed-convex in the middle, sometimes rapidly sloping in all directions, at others concave in the umbonal region ; as a rule very unsymmetrical. The brachial valve is deep, more regularly convex and has a full rounded umbo and a conspicuous median sinus. On the interior the pedicle-valve bears an extremely high median septum which is united with the dental ridges near the apex. The cardinal process is high, erect and deeply bilobed, each of its apophyses being strongly grooved on its posterior face. Other internal characters unknown.

The surface of both valves is covered by fine, elevated, thread-like striæ increasing very slowly by intercalation. The edges of these striæ bear numerous minute asperites which may be due to the crossing of fine concentric lines. Irregular lines and wrinkles of growth are abundant near the margins.

Upper Coal Measures. *Near Kansas City, Missouri.*

Derbya cymbula, sp. nov.

PLATE XI b, FIGS. 2, 3.

Shell large ; marginal outline transversely subelliptical. Hinge-line straight, its length being about two-thirds the greatest diameter of the shell On the pedicle-valve the cardinal area is high, its base being one-third longer than its sides, and it may be somewhat unsymmetrical from distortion. Its surface is finely striated both longitudinally and transversely, and is divided into an outer and inner portion by two lines diverging from the apex and meeting the hinge-line half-way between its extremities and the edges of the deltidium. Deltidium broad at the base, rapidly narrowing for one-third its length,

thence tapering more gradually to the apex ; its surface is marked by a well-defined median groove for its entire extent. The surface of the valve is elevated in the umbonal region and slopes somewhat irregularly to a low depression over the pallial region and about the margins. The brachial valve is broadly concave at the umbo, but rapidly becomes regularly convex, the greatest convexity being in the middle of the valve, whence it slopes almost equally in all directions. There is no evidence of a tendency to irregular growth in this valve.

Surface covered with numerous fine, sometimes irregular striæ, increasing by implantation. Over the umbonal and pallial regions these striæ are of about equal size, but about the margins the tendency to fasciculate arrangement is more apparent. Interior structure, except the existence of a median septum in the pedicle-valve, unknown.

Upper Coal Measures. *Near Kansas City, Missouri.*

Derbya affinis, sp. nov.

PLATE XIb, FIGS. 4, 5.

Shell subsemicircular in outline, somewhat transverse. Hinge-line straight, nearly equaling the greatest diameter of the valves. Cardinal area of the pedicle-valve high, its greatest height being about equal to one-third the length of the hinge-line ; divided by diverging lines as in the preceding species and crossed by conspicuous horizontal and fainter vertical striations. This area is often much distorted. Deltidium having a width at the base equal to one-fifth the length of the hinge-line ; it tapers evenly to the apex and bears a median groove on its surface. The umbo is elevated, but the surface of the valve becomes depressed, irregular in growth and concentrically wrinkled, though not concave anteriorly. Brachial valve faintly depressed at the apex, but rapidly becoming convex, the greatest convexity being in the umbonal region, whence the slope is quite regular in all directions, being somewhat more abrupt toward the cardinal extremities. This valve also shows a slight tendency to unsymmetrical growth in the umbonal region.

Surface covered by sharply defined, sub-equal radiating striæ, which increase by implantation. The grooves between these striæ are deep, and both striæ and grooves are crossed by fine concentric lines, which on the former produced a series of sharp asperities. Interior, with the exception of the median septum in the pedicle-valve, unknown.

Upper Coal Measures. *Near Kansas City, Missouri.*

There are many points of similarity in the *Orthis Kaskaskiensis*, McChesney, from the Kaskaskia limestone, *Derbya cymbula* and the species under consideration. All have the same general aspect. In *O. Kaskaskiensis* the brachial valve is most convex at the umbo, the pedicle-valve generally concave and the hinge-line equal to the greatest diameter of the shell; in *Derbya affinis* the brachial valve also has its greatest convexity at the umbo, but the hinge-line is considerably shorter than in McChesney's species, and there is a notable difference in the character of the surface striæ; while in *Derbya cymbula* the convexity of the brachial valve is greatest at its center, the hinge-line very short and the pedicle-valve concave or depressed only over the pallial region.

Derbya (?) biloba, sp. nov.

PLATE XI, FIGS. 4, 5.

Shell small, obcordate in outline. Hinge-line short and straight, its length being considerably less than one-half the width of the shell. On the pedicle-valve the cardinal area is moderately high and slightly arched backward; delthyrium covered. The surface of the valve is somewhat depressed or flattened over the pallial region. The brachial is deeper and more convex; the umbo is full but not elevated, and just in front of the apex there begins a broad and conspicuous sinus which widens rapidly and renders the shell bilobate on its anterior margin.

Surface covered with numerous fine radiating striæ. Interior unknown.

Upper Coal Measures. *Winterset, Iowa.*

Streptorhynchus Ulrichi, sp. nov.

PLATE XIb, FIG. 15.

Shell of comparatively large size for this genus. General contour subtrihedral. Hinge-line shorter than the greatest diameter of the valves. Cardinal area high, somewhat incurved and distorted; sides considerably shorter than the base. Deltidium broad. Marginal outline of the pedicle-valve, from hinge-line forward, semiovate, somewhat irregular, contracted toward the hinge and expanding in the pallial region. The interior of the pedicle-valve shows strong teeth, the dental lamellæ extending downward and enclosing the posterior portion of an ovate muscular scar. There is no median septum. External surface convex in the upper part becoming depressed toward the anterior margin; quite irregular in growth, being crossed by more or less conspicuous concentric ridges or varices; covered with numerous fine radiating, subequal striæ which increase by implantation.

Brachial valve not known.

Chester limestone. *Crittenden county, Kentucky.*

Christiania subquadrata, sp. nov.

1883. *Leptæna subquadrata*, Hall. Rept. State Geologist N. Y. for 1882, pl. (xv) 46, figs. 32, 33.

PLATE XV, FIGS. 32, 33; PLATE XVa, FIG. 36; PLATE XX, FIGS. 18-20.

Shell small, elongate, semielliptical in outline, strongly convexo-concave. Hinge-line short, straight, not equaling the greatest diameter of the valves anteriorly. In the pedicle-valve the umbo is full, rounded and incurved, with the apex obscure; the cardinal area is moderately broad and bears an open delthyrium which terminates above in a circular foramen. The teeth are short, divergent and continued into ridges which form the lateral margins of two linguiform, muscular scars, traversing the shell for almost its entire length. These scars enclose two much shorter impressions. In the brachial valve the area is narrow, the cardinal process bipartite on its anterior face, each of the lobes being grooved behind. The crural plates are very long and divergent, the upper portion of each terminating in an elevated

extremity; the lower portion produced on each side as a strongly elevated ridge, curving slightly inward on the sides, then outward on approaching the anterior margin of the valve; each branch recurving and passing backward, parallel to the median axis, as far as the base of the cardinal process. The symmetrical spaces thus formed are each divided transversely by a somewhat lower vertical ridge. Between the inner muscular walls in the median line is a low, rounded, longitudinal ridge.

The surface is smooth or covered with concentric, usually somewhat squamous lines of growth.

Lower Helderberg group. *Perry county, Tennessee.*

Leptænisca adnascens, sp. nov.

PLATE XVA, FIGS. 22, 23.

Shell small, very irregular in outline; cemented to shells of other brachiopods, especially of Orthis, by the entire external surface of the pedicle-valve. Hinge-line making the greatest diameter of the shell. Cardinal area well developed on the pedicle-valve and bearing a convex deltidium. Internal characters as in *L. tangens.* Brachial valve prominent at the beak, elevated in the umbonal region and slightly depressed anteriorly. Surface smooth or with irregularly concentric wrinkles.

Lower Helderberg group (Shaly limestone). *Near Clarksville, N. Y.*

Leptænisca tangens, sp. nov.

PLATE XVA, FIGS. 24-30.

Shell transverse; hinge-line making the greatest diameter; contour regularly convexo-concave; attached by the apical or umbonal portion of the pedicle-valve, usually fronds and twigs of bryozoa. Cardinal areas narrow; delthyrium covered. In the pedicle-valve teeth not prominent but continued into strong, converging lamellæ which nearly enclose an oval muscular area; this area is divided by a median septum. External surface convex; bi-

lobed by a more or less conspicuous median furrow. Brachial valve strongly concave.

Surface smooth, with a few inconspicuous concentric growth-lines, and faint radiating striæ on the inner lamellæ toward the margins.

Lower Helderberg group (Shaly limestone). *Near Clarksville, N. Y.*

Chonostrophia Helderbergia, sp. nov.

PLATE XVB. FIG. 14.

Shell tenuous, semi-elliptical in outline. Hinge-line straight and making the greatest diameter of the valves. Valves nearly flat, the pedicle-valve being gently concave and the brachial correspondingly convex. Cardinal areas very narrow; marginal spines not observed. Teeth of the pedicle-valve well developed on either side of the moderately broad delthyrium; at their bases arises a median septum, strongest at the point of beginning and continuing for one-half the length of the valve. In the brachial valve the crural plates are very short, subparallel to the hinge-line and apparently coalesced with the short cardinal process. No traces of muscular scars retained.

Surface covered with a great number of exceedingly fine, subequal radiating striæ, all of which are apparent on the interior of the shell, even to the bases of the teeth and crural plates.

Lower Helderberg group (Shaly limestone). *Albany county, N. Y.*

Strophalosia Rockfordensis, sp. nov.

PLATE XVIIA, FIGS. 1-3.

Shell semielliptical in outline, somewhat elongate. Hinge-line scarcely as long as the greatest diameter of the valves. Cardinal area well developed on each valve, that of a pedicle-valve bearing a convex deltidium; scar of attachment on the pedicle-valve covering only the apical region. Surface regularly convex, depressed toward the cardinal angles; bearing scat-

tered spines, of which there is a well-defined row of six or seven on the cardinal margin. There are faint, irregularly concentric wrinkles among the spine-bases. Apex of the brachial valve convex but the valve rapidly becomes concave, being of somewhat less curvature than the opposite valve. Surface with conspicuous, irregular, concentric corrugations, and a few short spines over the pallial region.

Length of the original specimen, 9 mm.; width along hinge-line, 10 mm.

Upper Devonian. *Rockford, Iowa.*

ERRATA.

Page 57, line 12 from bottom; for "Plate I" read "Plate II."

Page 75, line 6; for "position" read "portion."

Page 83, line 5; for "LEOTOBOLUS" read "LEPTOBOLUS."

Page 99, line 23; for "and" read "are."

Page 99, line 24; insert "which" after "25–29)."

Page 108, under fig. 60; for "pedicle" read "brachial;" for "brachial" read "pedicle."

Page 139, line 8 from bottom; SHARPE's specimens came from Cincinnati, Ohio, or vicinity, and were probably examples of the form now known as *T. millipunctata*, Hall, as EMMONS' *T. terminalis* has not been found in that locality. SHARPE, however, mentioned EMMONS' species as the type, and it may be best to retain the New York form as such.

Page 173, line 4; for "*Lingula lingulata*" read "*Lingula linguata*."

Page 185, line 18; for "STROPHODONTA" read "STROPHEODONTA."

Page 194, second paragraph. The deltidium of *Orthis? Laurentina* is minutely perforate.

Page 288, line 15; *dele* "are."

Page 303, line 2; for "XVA" read "XVB."

Page 308, line 5; for "*C. undulatus*" read "*C. undulata*;" for "*C. Novascoticus*" read *C. Novascotica*." Corrected in part of the edition.

Page 328, line 1; for "1847" read "1867."

Explanation of Plate I, line 25; insert "(?)" after "*Lingula Vanhornii*, Miller"; line 28, *dele*; read "Trenton horizon. Frankfort, Kentucky."

Explation of Plate IVE, continued, line 8; for "*Orbiculoidea pulchra*" read "*Orbiculoidea Herzeri*."

Explanation of Plate IVF, line 33; for "*Orbiculoidea pulchra*" read "*Orbiculoidea Herzeri*."

INDEX

TO PALÆONTOLOGY OF NEW YORK, VOL. VIII. PART I.

I. Register of Authors' Names.

(These references do not include names used in association with specific designations.)

II. Register of Genera.

(Names in *italics* are synonyms; figures in **full-face** type denote place of description.)

III. Register of Species.

(Names in *italics* are synonyms: figures in **full-face** type after new species denote the place of description.)

REPRODUCTIONS OF DALMAN'S PLATES I AND II.

Accompanying his paper entitled : "Uppställing och Beskrifning af de i Sverige funne Terebratuliter.

See Page 192

" Explicatio Figurarum :

" Tab. I. Fig. 1, Leptæna rugosa His.

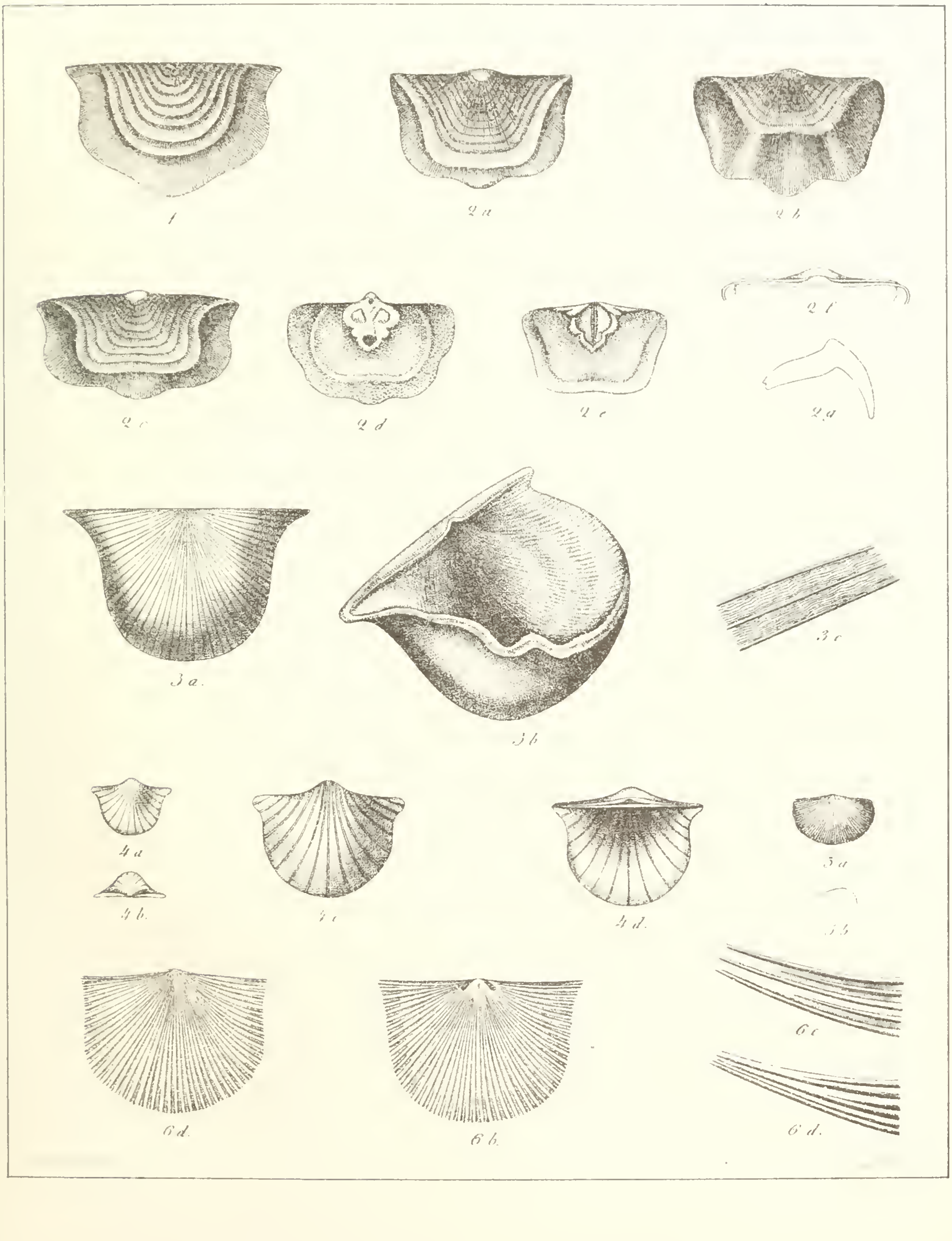
Fig. 2, a, b, Leptæna depressa Sow., c, ejusdem Var. ; d, valva intus visa ; e, valva altera intus visa, cum dentibus cardinalibus ; — f, margo cardinalis ; g, sectio ambarum longitudinalis, a latere visa, ut repræsentaret valvas compressas et angulum, quem format margo reflexus.

Fig. 3, a, Leptæna euglypha : 3, b, eadem a latere visa, magn. nat. — 3, c, striæ in testa elevatæ, cum interstitiis undulatis, *magn. auct.*

Fig. 4, a, b, Leptæna transversalis : magn. nat. — 4, c, d, eadem *magn. auct.*

Fig. 5, a, Orthis striatella : valva major ; b, figura hujus valvæ convexitatem repræsentans.

Fig. 6, a, Orthis Pecten : valva major, — b, valva altera ; c, valvæ majoris striæ, *magn. auct.* ; d, valvæ alterius striæ, *magn. auct.*


1
2 a
2 b
2 c
2 d
2 e
2 f
2 g
3 a.
3 b
3 c
4 a
4 b.
4 c
4 d.
5 a
5 b
6 c
6 d.
6 b.
6 d.

"Explicatio Figurarum.

"Tab. 11. Fig. 1, a, Orthis zonata, valva major, retusa; b, eadem, valva minor; c, d, e, eadem species a basi et a lateralibus visa.

Fig. 2. Orthis callactis a.

Fig. 3. a, b, c. d: Orthis calligramma.

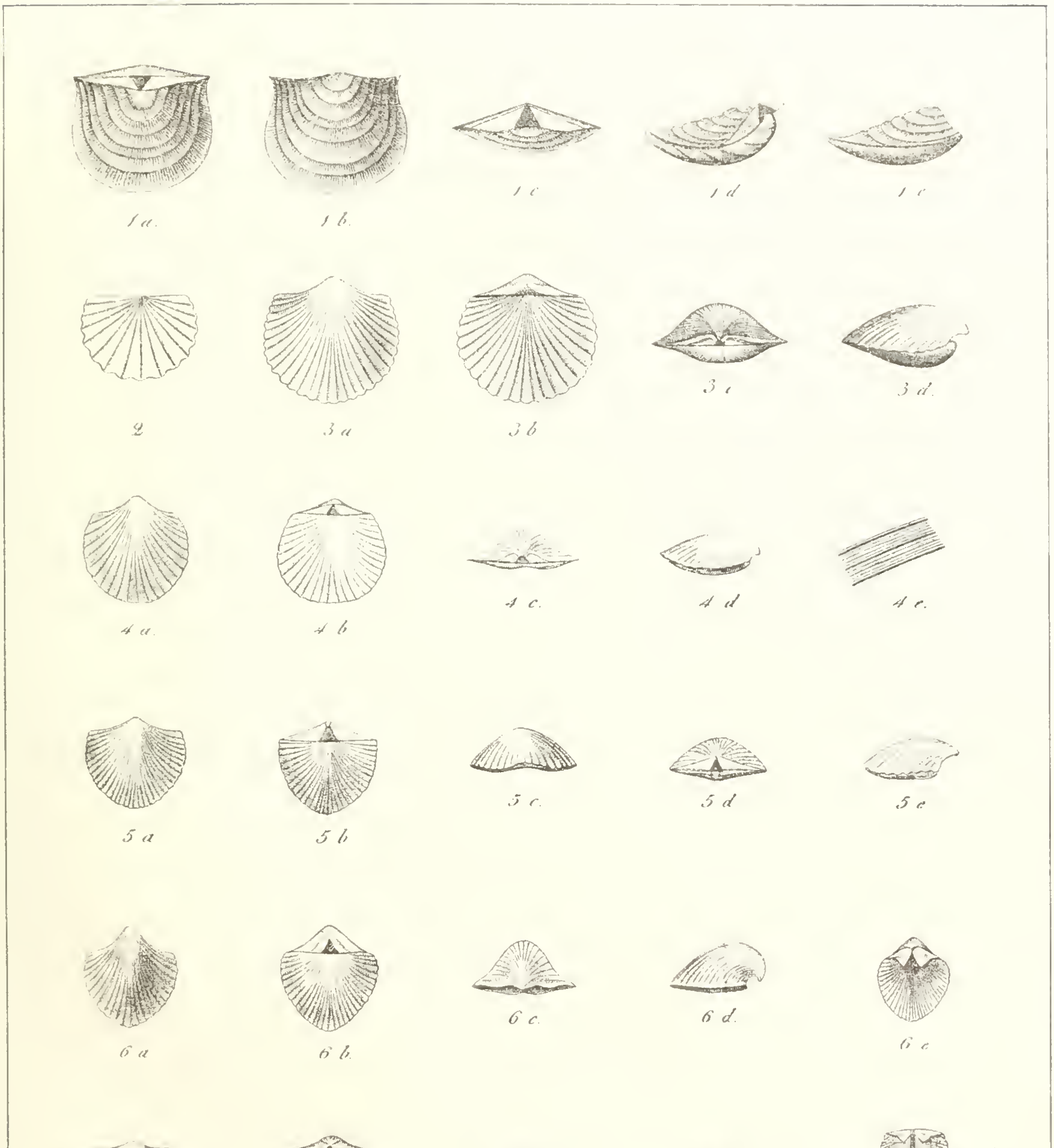
Fig. 4, a, b, c, d, Orthis testudinaria; — 4, e: sulci cum striis, *magn. auct.*

Fig. 5. a, b. c. d, e: Orthis basalis

Fig. 6. a, b, c, d: Orthis elegantula; — 6, e: hujus speciei valva major intus visa; 6, f: valva minor intus visa; g, valva minor a basi visa, ut repræsententur dentes cardinales.

Fig. 7. a, b, c, d: Orthis demissa."

DALMAN'S PETREFACTA SUECANA.



PLATES AND EXPLANATIONS.

PLATE I.

Legend. g. Umbonal scars.
l. Lateral scars.
k. Middle laterals.
j. Anterior laterals.
l. Outside laterals.
x. Concrete laterals.
h. Central scars.
c. Concrete centrals.
i. Transmedian scars.
d. Cardinal area.
s. Median septum.
s'. Lateral septa.
vs. Vascular trunks.
v. Vascular branches.

LINGULA, Bruguière.

Page 2.

Glossina, Phillips.

Page 15.

Lingula (Glossina) acuminata, Conrad.

Fig. 1. A pedicle-valve from which most of the substance of the shell has been exfoliated, presenting a cast of the internal surface, which retains the impressions of the fine radiating, and coarser, more distinct, concentric lines. The thickness of the shell-substance and the undulating character of its laminæ, is shown on the marginal portion of the figure, but no traces of muscular impressions are discernible. × 2.

Fig. 2. A brachial valve of the same species, from which the shell is partially exfoliated. × 2.

Calciferous sandstone. *Saratoga, N. Y.*

Lingula (Glossina) riciniformis, Hall.

Fig. 3. A pedicle-valve (?) from which the outer layers of the shell are somewhat exfoliated; showing the strong median radii, which are evidently more distinctly developed on the interior than on the exterior of the shell. × 3.

Trenton limestone. *Middleville, N. Y.*

Lingula Vanhornii, Miller.

Fig. 4. The interior of a pedicle-valve; showing the undifferentiated lateral muscular scars, and the low, median septum. × 3.

Hudson River group. *Cincinnati, Ohio.*

Lingula Procteri, Ulrich.

Fig. 5. The brachial valve of an internal cast; showing the concrete laterals (x), the anterior laterals (j), and the septum (s). × 1.5.

Fig. 6. The opposite valve of the same specimen; showing the progressive lateral and median impressions (septum) and the vascular markings. × 1.5.

Hudson River group. *South Covington, Kentucky.*

Fig. 7. An internal cast of a brachial valve; showing the lateral scars and long median septum. × 2.

Hudson River group. *Cincinnati, Ohio.*

Lingula Philomela, Billings.

Fig. 8. A pedicle-valve (?), imperfect in the umbonal region; illustrating one extreme of outline attained by shells of this genus. Natural size.

Trenton limestone. *Florenceville, Howard county, Iowa.*

Lingula lamellata, Hall.

Figs. 9, 10. External and internal views of the same specimen. Natural size.

Niagara group. *Lockport, N. Y.*

Lingula cuneata, Conrad.

Fig. 11. An internal cast of the pedicle-valve; showing the broad, low, median septum and the faint lateral scars. × 2.

Fig. 12. The brachial valve, with an ill-defined muscular scar and traces of the vascular sinuses.

Medina sandstone. *Albion, N. Y.*

Lingula quadrata (Eichwald), Hall.

Fig. 13. A large example, from which much of the shell has been exfoliated; showing the median septum, which is frequently more strongly developed, and the projection of the umbonal region of the pedicle-valve beyond the apex of the brachial. The prominence of the latter feature is to some degree due to the displacement of the valves.

Trenton limestone. *Trenton Falls, N. Y.*

Lingula Iowensis, Owen.

Fig. 14. The interior of a brachial valve, probably referable to this species; showing the conspicuously developed median septum, the well-defined central scars (h), and the progressive laterals (x). Natural size.

Galena limestone. *Fountain, Minnesota.*

Lingula spatulata, Vanuxem.

Fig. 15. A pedicle-valve (?), retaining the shell, and showing evidence of a median septum in the umbonal region. × 6.

Genesee slate. *Canandaigua Lake, N. Y.*

Lingula compta, sp. nov.

Fig. 16. A specimen of the brachial valve (?); showing the lateral impressions and the median septum extending to the anterior margin. × 2.

Hamilton shales. *Canandaigua Lake, N. Y.*

Lingula complanata, Williams.

Fig. 17. The interior of a brachial valve; showing the fulcra of the lateral muscles. × 2.

Portage group. *Ithaca, N. Y.*

Lingula sp ? cf. Cuyahoga, Hall.

Fig. 18. A pedicle-valve, retaining a portion of the shell-substance, and showing the position of the lateral scars. × 2.

Chemung group. *Panama, N. Y.*

Lingula anatina, Lamarck.

Fig. 19. The interior of the pedicle-valve; showing the character of the muscular scars and septa as they appear when the muscular bands and the mantle are wholly removed. Natural size.

Fig. 20. Brachial valve of the same. Natural size.

Recent. *Philippine Islands.*

Lingula Elderi, Whitfield.

Figs. 21, 22. Copies of the lithographic figures given by Mr. Whitfield (Geol. Surv. Wisconsin, vol. iv, pl. 27, figs. 4, 5), of the interiors of the pedicle and brachial valves, respectively. Drawn from a cast which preserves the internal characters with remarkable completeness. × 2.

Trenton limestone. *Near Rochester, Minnesota.*

Lingula cf. densa, Hall.

Fig. 23. The interior of a pedicle-valve; showing the septum and lateral scars. × 2.

Hamilton shales. *Centerfield, N. Y.*

DIGNOMIA, Hall.

Page 14.

Dignomia alveata, Hall.

Fig. 24. A cast of a brachial valve; showing the long, sharp median septum and the fainter diverging lateral septa. Natural size.

Hamilton shales. *Fultonham, N. Y.*

Fig. 25. A portion of the interior of a large pedicle-valve (?), with a shorter and broader median septum, and distinct lateral septa. Natural size.

Hamilton shales. *Canandaigua Lake, N. Y.*

PLATE I—Continued.

LINGULA, Bruguière.

Page 2.

Lingula punctata, Hall.

Fig. 26. An enlargement of the external surface; showing the character of the ornamentation. × 12.

Fig. 27. A cast of the interior of the brachial valve; showing the indistinct lateral scars, the vascular sinuses and their ramifications. × 2.

Fig. 28. An internal cast of a pedicle-valve; showing the compound lateral scars and the broad centrals × 2.

Hamilton shales. *Canandaigua Lake, N. Y.*

Lingula Delia, Hall.

Fig. 29. The type-specimen, a brachial valve (?), retaining most of the surface ornamentation, and showing a very strong median septum. × 2.

Hamilton shales. *Canandaigua Lake, N. Y.*

Lingula scutella, sp. nov.

Fig. 30. An internal cast, indicating that the muscular region of the valve was depressed, instead of thickened and elevated as usual. × 2.

Chemung group. *Alleghany county, N. Y.*

Lingula Whitii, Walcott.

Fig. 31. A copy of Mr. Walcott's figure of the brachial valve of this species (Palæont. Eureka District, pl. xiii, fig. 3). × 2.

Lower Devonian. *Atrypa Peak. Eureka District. Nevada.*

Lingula Melie, Hall.

Fig. 32. A valve, showing the broad, low median septum, with its elevated margins. × 2.

Waverly group. *Berea, Ohio.*

Lingula (Glossina) flabellula, sp. nov.

Fig. 33. A very large example, from which a portion of the shell has been exfoliated, without showing any traces of muscular markings. The anterior margin is represented with too great a curvature. Natural size.

Waverly group. *Sciotoville, Ohio.*

Fig. 34. A smaller valve, exposing the inner laminæ of the shell, with faint radiating lines. Natural size.

Berea grit. *Berea, Ohio.*

LINGULEPIS, Hall.

Page 59.

Lingulepis pinniformis, Owen.

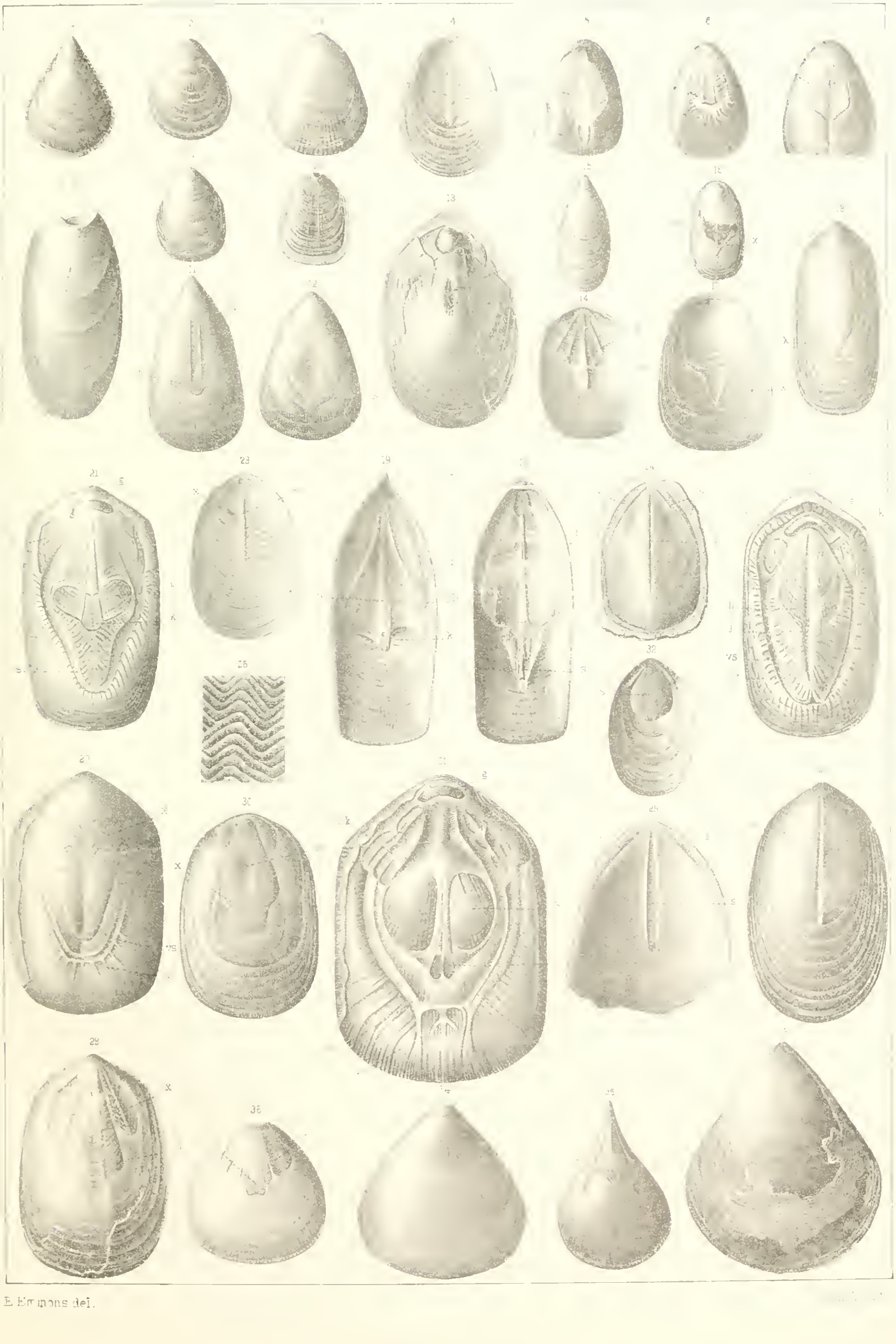
Fig. 35. An internal cast of a pedicle-valve; showing the faint median septum, and the elongate muscular scar, with its lateral and central divisions. × 2.

Fig. 36. An internal cast of the brachial valve, in which the muscular impression is flabellate, the central and lateral scars being quite distinct, the latter somewhat bilobed. × 2.

Potsdam sandstone. *Falls of the St. Croix, Minnesota.*

BRACHIOPODA

Generic Illustrations



E Emmons del.

PLATE II.

Legend. g. Umbonal scars.
g'. Cardinal scars.
l Lateral scars.
h. Central scars.
c. Concrete centrals.
z. External scars.
b. Parietal scar.
cr Crescent.
p. Pedicle-groove.
ps. Pedicle-sheath.
d. Cardinal area.
cc. Cardinal callosities.
pl. Platform.
s. Median septum.
vs. Vascular sinuses.

LINGULELLA, Salter.

Page 55.

Lingulella cælata, Hall.

Fig. 1. A pedicle-valve, from which the shell is partially exfoliated; showing traces of the curved lateral and the central scars. × 2.

Fig. 2. A pedicle-valve, retaining most of the shell; showing the surface ornamentation and the opening of the foramen; (a) longitudinal section, showing the elevation of the beak; (b) posterior elevation. × 2.

Fig. 3. A brachial valve; showing the central and lateral muscular impressions, and a very sharply defined scar (z) which, if not adventitious, may be homologous with the external scars in *Obolella crassa*, or the terminal crescent scars in the Trimerellids. × 2.

Fig. 4. An incomplete cast of the same valve. × 2.

Middle Cambrian. *Near Troy, N. Y.*

Lingulella Dawsoni, Matthew.

Fig. 5. A cast of the interior of the pedicle-valve. × 3.

St. John group. *Portland, New Brunswick.*

Lingulella (?) paliformis, Hall.

Fig. 6. A view from the dorsal side of both valves in normal juxtaposition; showing the elevation of the cardinal area in the pedicle-valve, and its pedicle-slit, which by compression appears through the exfoliated apical portion of the brachial valve. × 2.

Hamilton shales. *Shurger's Glen, Cayuga Lake, N. Y.*

Fig. 7. A pedicle-valve, showing a faint slit along the position of the pedicle-groove. × 3.

Hamilton shales. *Pratt's Falls, Onondaga county, N. Y.*

Fig. 8. A pedicle-valve, which has been compressed along the filling of the pedicle-slit. × 3.

Hamilton shales. *Shurger's Glen, Cayuga Lake, N. Y.*

Lingulella Stoneana, Whitfield.

(*Lingulella aurora*, var., Hall.)

Fig. 9. Dorsal view of a specimen. Natural size.

Fig. 10. The same, enlarged to three diameters; showing the characters of the cardinal area.

Fig. 11. An enlargement of the surface; showing the concentric growth-lines crossed by undulating lamellose striæ.

Potsdam sandstone. *In the upper, variegated magnesian layers, near Mazomanie, Wis.*

Lingulella aurora, Hall.

Fig. 12. A dorsal view of the specimen; showing the high cardinal area, and its pedicle-groove. × 3.

Fig. 13. Another specimen, similarly enlarged.

Potsdam sandstone. *Near Mazomanie, Wisconsin.*

BARROISELLA, gen. nov.

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BARROISELLA SUBSPATULATA, Meek and Worthen.

Fig. 14. The cardinal portion of the pedicle-valve; showing the conspicuous pedicle-groove, which, in this instance, has been somewhat widened by compression and fracture; also the articular bosses or cardinal fulcra on the basal margin. × 5.

Fig. 15. The interior of a pedicle-valve; showing the cardinal area, muscular and other markings. × 3.

Fig. 16. The interior of a brachial valve, with characteristic features. × 3.

Black slate (Genesee slate). *White River, near Rockford, Indiana.*

LINGULASMA, ULRICH.

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LINGULASMA SCHUCHERTI, Ulrich.

Fig. 17. The apical portion of the internal cast represented in fig. 22; enlarged to show the impression of the pedicle-sheath (ps), or internal continuation of the cardinal area. × 3.

Fig. 18. The interior of a brachial valve; showing the character of the muscular impressions, the platform and the very strong septum. Drawn from a gutta-percha impression of an internal cast. Natural size.

Fig. 19. Profile view of an internal cast; showing the relative thickness of the platforms on the two valves.

Fig. 20. The interior of the pedicle-valve; showing the pedicle-sheath (ps), the indistinctly defined muscular impressions, the low platform and inconspicuous septum. This drawing is also made from a gutta-percha impression. Natural size.

Fig. 21. An enlargement of the surface ornamentation. The tubercles are sharply defined, and round on the median portions of the shell, but become elongated and less distinct toward the lateral margins. × 5.

Fig. 22. A natural cast; showing the interior of the brachial valve.

Fig. 23. The opposite side of the same specimen; showing the internal characters of the pedicle-valve.

Hudson River group. *Wilmington, Illinois.*

LINGULOPS, HALL.

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LINGULOPS NORWOODI, James.

Fig. 24. The exterior of a pedicle-valve. × 4.

Fig. 25. The interior of a pedicle-valve, drawn from a gutta-percha impression of a natural cast. The pedicle-groove is faint but evident; within the broad posterior margin lie the compound umbonal or cardinal impressions: the scalloped posterior and the median muscular scars are very sharply defined. × 8.

Fig. 26. The interior of a brachial valve; showing the low, elongate platform. The punctæ on the surface of the platform appear to be regularly arranged but are probably accidental markings. Drawn from a gutta-percha impression. × 6.

Hudson River group. *Cincinnati, Ohio.*

LINGULOPS WHITFIELDI, Hall.

Fig. 27. The exterior of a pedicle-valve. × 6.

Fig. 28. The interior of a pedicle-valve; the original specimen. The figure has been drawn from a gutta-percha impression of an internal cast, and shows the compound cardinal area (seen also in fig. 30), the inner portion of which is concentrically striated; the crescent (cr); the scalloped parietal scar and median muscular scars; the narrow longitudinal septum flanked by broad, rounded ridges continued from the visceral region. No traces of vascular impressions are visible on the specimen. × 12.

Fig. 29. An imperfect interior, probably belonging to the same (pedicle-) valve. × 12.

Fig. 30. The interior of the brachial valve, drawn from a gutta-percha impression; showing the double cardinal area, a faint pedicle-depression, the crescent (cr), the parietal (?) scars, the platform, and the vascular sinuses with their outer ramifications. × 10.

Hudson River group. *Maquoketa Creek, 12 miles north-west of Dubuque, Iowa.*

BRACHIOPODA

Generic Illustrations

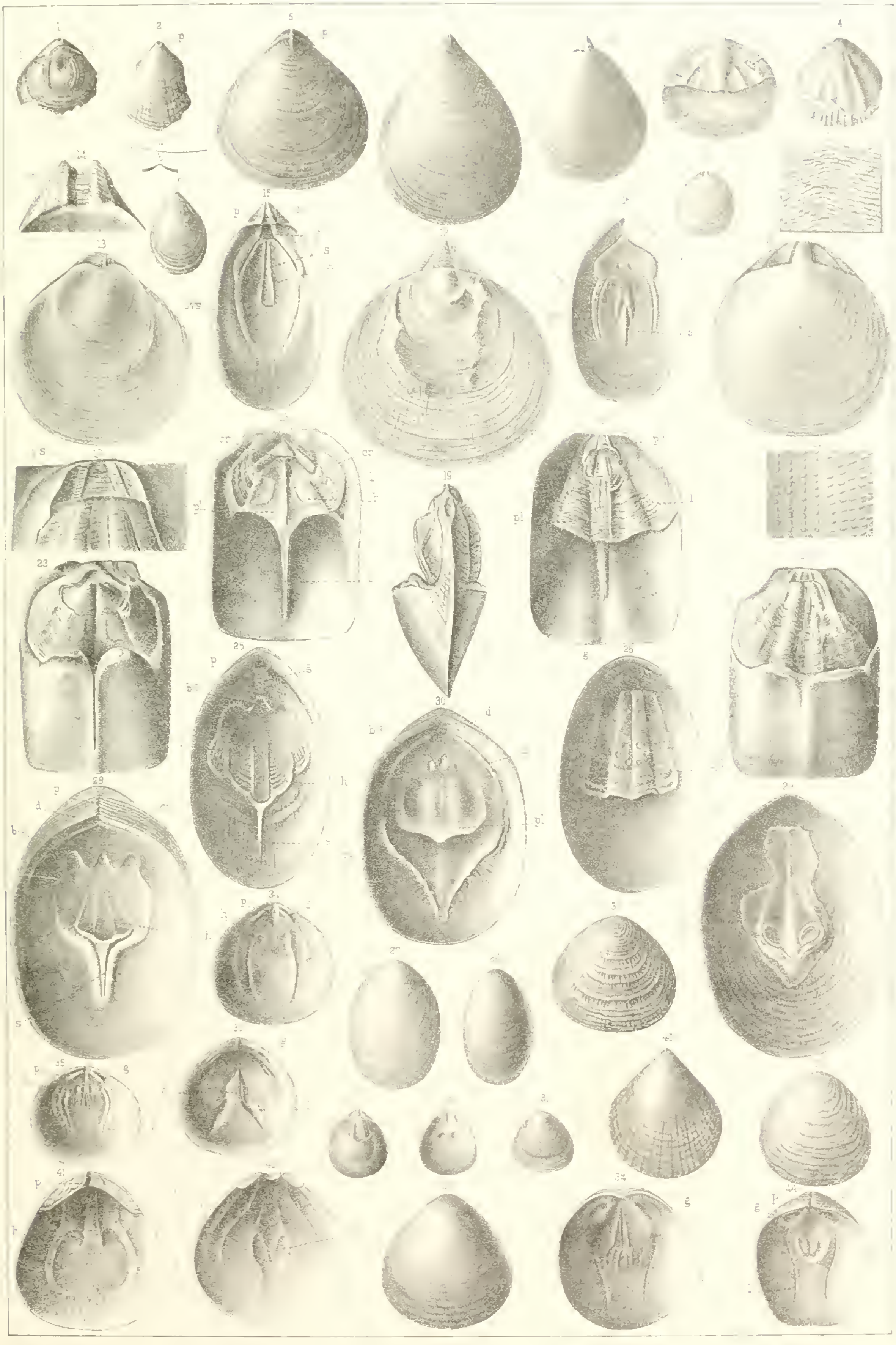

PLATE II—Continued.

OBOLELLA, Billings.

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Obolella crassa, Hall.

Fig. 31. The exterior of a valve. Natural size.

Fig. 32. The same, enlarged; showing the radiating striæ between the lamellose growth-lines. × 2.

Fig. 33. Another valve, similarly enlarged, in which the radiating lines do not appear. This is the specimen originally described as *Avicula desquamata*, Hall (Pal. N. Y., vol. i. 1847).

Fig. 34. The interior of a pedicle-valve: showing the pedicle-groove, the cardinal, lateral and central muscular scars. × 2.

Fig. 35. The interior of another, but smaller, pedicle-valve; showing the same features. × 2.

Fig. 36. The interior of the brachial valve; showing the faint pedicle-groove, the cardinal, external, central and lateral muscular impressions. × 2.

Middle Cambrian. *Near Troy, N. Y.*

Obolella polita, Hall.

Fig. 37. The exterior of a valve. × 4.

Fig. 38. The interior of a pedicle-valve: showing the central and lateral muscular impressions. × 2.

Fig. 39. An internal cast of the opposite (?) valve. × 2.

Fig. 40. The interior of a brachial valve × 6.

Fig. 41. The interior of a pedicle-valve. × 6.

(Figs. 40 and 41 are from the original drawings represented in the Sixteenth Rept. N. Y. State Cab. Nat. Hist., pl. vi. figs. 20, 21.)

Potsdam sandstone. *Trempaleau, Wisconsin.*

Obolella gemma, Billings.

Fig. 42. The exterior of a pedicle-valve. × 6.

Fig. 43. (34 in error, last line of figures.) The interior of a brachial valve; showing the muscular impressions. × 6.

Fig. 44. The interior of a pedicle-valve: showing the cardinal area, pedicle-groove and muscular impressions. × 6.

(The originals of figs. 1, 2, 4, 34, 35, 36, 42, 43, 44, are in the collection of Mr. S. W. Ford.)

PLATE III.

Legend: l. Laterals.
c. Centrals.
sc. Subcardinals or postmedians.
cr. Crescent.
e. Externals.
x. Composite posteriors.
P. Pedicle-groove.
F Foramen.
f. Foraminal pits.
s. Septum (median).
s′. Septum (lateral).
o. Vascular trunks (oviducts ?).
d′. Subapical area.
cb. Cardinal bosses.
fc. Foraminal callosity.

LEPTOBOLUS, Hall.

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Leptobolus insignis, Hall.

Fig. 1. An internal cast of a pedicle-valve: showing the long, curved lateral scars and a faint indication of the posterior muscular depression. × 10.

Fig. 2. An internal cast of the brachial valve, similarly enlarged, and showing the median septum and two lateral grooves, which correspond either to the scars (z) seen in fig. 6, or to the lateral septa (s′) in fig. 10.

Utica slate. *Holland Patent, N. Y.*

Fig. 3. The exterior of the shell: showing the concentric and radiating striae. × 8.

Utica slate. *Middleville, N. Y.*

Fig. 4. The interior of a pedicle valve: showing the cardinal area and groove, and the thick, calloused fulcra of the lateral muscles. × 15.

Fig. 5. Another interior of this valve, in which the transverse extensions of the lateral fulcra are continuous. The posterior depressed area bears the impression of the central muscles, and indications of a subdivision of the pitted surface into differentiated scars. × 15.

Fig. 6. The interior of a brachial valve; showing the grooved area, conspicuous median septum and faint lateral scars

Hudson River group (Utica horizon). *Covington, Kentucky.*

Leptobolus occidentalis, Hall.

Fig. 7. The exterior of the shell. × 8.

Dark shale of the Utica horizon. *Hawley's Mill, 12 miles north-west of Dubuque, Iowa.*

Leptobolus lepis, Hall.

Fig. 8. The interior of a pedicle-valve; showing the cardinal groove and the diverging septa. × 12.

Fig. 9. A cast of the interior of the pedicle-valve; showing the central scar and the transverse extension of the laterals. × 12.

Fig. 10. The interior of the brachial valve; showing the grooved cardinal area and the median and lateral septa, each of which is bifurcate at its extremity. × 12.

Hudson River group. *Licking River, Ohio.*

SCHIZOBOLUS, Ulrich.

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Schizobolus truncatus, Hall (sp.).

Fig. 11. The exterior of a pedicle-valve. × 3.

Genesee slate. *Western New York.*

Fig. 12. The interior of a pedicle-valve, drawn from one of Mr. Ulrich's original specimens; showing the pedicle-slit, the composite muscular scars abutting against the median septum, and the long, curved lateral scars. × 5.

Black slate (Genesee). *Madison county, Kentucky.*

Fig. 13. The exterior of the brachial valve. × 3.

Genesee slate. *Western New York.*

Fig. 14. The interior of the brachial valve; showing the septum and faintly defined muscular impressions. × 5.

Black slate (Genesee). *Madison county, Kentucky.*

BRACHIOPODA.

Generic Illustrations

 Plate III

E. Emmons del. Phil. Ast lith.

ELKANIA, FORD.

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ELKANIA DESIDERATA, Billings (sp.).

Fig. 15. The interior of a pedicle-valve ; showing the deep central impression (pedicle-pit of FORD), sub-cardinal, crescentic and external scars, the diverging vascular (genital ?) furrows and the broad, deep lateral depressions, probably not of muscular origin. × 3.

Fig. 16. The counterpart of the same, similarly enlarged.

Fig. 17. The interior of the brachial valve, with the impressions of the central and lateral muscles and crescent. × 3

Fig. 18. The counterpart of the same ; showing the muscular callosity or incipient platform. × 3.

Fig. 19. An enlargement of the surface of one of the intermediate corneous layers of the shell ; showing its irregularly granulose surface. × 6.

Quebec group. *Pointe Lévis.*

The above figures are made from Mr. E. BILLINGS' original specimens of the species.

DISCINOPSIS, gen. nov. (MATTHEW).

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DISCINOPSIS GULIELMI, Matthew.

Fig. 20. The exterior of a pedicle-valve ? ; showing the radiating and concentric lines, and a flattened apex which may indicate the position of the foramen. × 5.

Fig. 21. The interior of the pedicle-valve, with the lingniform median extension sharply defined, and showing the possible position of the foramen. × 5.

Fig. 22. The counterpart of the same. × 5.

Figs. 23, 24. Other interiors of the pedicle-valve, less satisfactorily preserved. × 5.

All are from the St. John group. *Portland, New Brunswick.*

ACROTHELE, LINNARSSON.

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ACROTHELE MATTHEWI, Hartt (sp.), var. PRIMA, Matthew.

Fig. 25. The exterior of the pedicle-valve ; showing the character of the surface ornamentation. × 3.

ACROTHELE MATTHEWI, Hartt, var. LATA, Matthew.

Fig. 26. The interior of the pedicle-valve ; showing the position of the foramen and the foraminal pits. × 3.

Fig. 27. An internal cast of the same valve. × 3.

Fig. 28. Profile of the latter. × 3.

St. John group. *Hanford Brook, New Brunswick.*

ACROTHELE MATTHEWI, Hartt (sp.).

Fig. 29. The interior of a brachial valve ; showing the median septum and adjacent muscular scars. × 3.

St. John group. *Portland, New Brunswick.*

Figs. 25 to 29 are from the original specimens figured by Mr. MATTHEW.

ACROTHELE SUBSIDUA, White.

Fig. 30. The interior of the pedicle-valve ; showing the foramen and foraminal pits. × 2.

Fig. 31. The interior of the brachial valve with a faint median septum. × 2.

Middle Cambrian. *Antelope Springs, Utah.*

PLATE III—Continued.

ACROTRETA, Kutorga.

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Acrotreta Baileyi, Matthew.

Fig. 32. An internal cast of a pedicle-valve: showing the grooved subapical area and the impression of the nipple-like swelling surrounding the foramen. × 4.

(Matthew, Trans. Roy. Soc. Canada, 1885, pl. iv, fig. 13c.)

Fig. 33. An internal cast of the brachial valve. × 4.

(Matthew, *op. cit.*, fig. 13.)

Fig. 34. The exterior of a pedicle-valve: showing the size of the outer foraminal aperture. × 4

St. John group. *Long Reach, King's county, New Brunswick.*

LINNARSSONIA, Walcott.

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Linnarssonia misera (?), Billings (sp.).

Fig. 35 An internal cast of a pedicle-valve: showing the impressions of the cardinal bosses and the foraminal callosity. × 6.

(Matthew, *op. cit.*, fig. 12c.)

Fig. 36. An internal cast of a brachial valve. × 6.

(Matthew, *op. cit.*, fig. 12.)

Fig. 37. An internal cast of a pedicle-valve. × 6.

St. John group. *Porter's Brook, St. John county, New Brunswick.*

Linnarssonia transversa, Hartt (sp.).

Fig. 38. An internal cast of a pedicle-valve; showing the inner foraminal aperture, the impressions of the foraminal callosity and cardinal tubercles. × 5.

(Matthew, *op. cit.*, fig. 11c.)

Fig. 39. The counterpart of the same. × 10.

Fig. 40. An internal cast of the brachial valve. × 5.

(Matthew, *op. cit.*, fig. 11.)

Fig. 41. Posterior view of the same. × 5.

Fig. 42. The counterpart of the same; showing the median and lateral septa and the large posterior scars. × 10.

St. John Group. *Porter's Brook, St. John county, New Brunswick.*

Linnarssonia pretiosa, Billings.

Fig. 43. The interior of a pedicle-valve. × 6.

Fig. 44. The interior of a brachial valve. × 6.

(See Dawson, Trans. Roy. Soc. Canada, vol. vii, Sect. iv, p. 53. 1889.)

Quebec group. *Island of Little Metis, Province of Quebec.*

PLATE IV.

Legend. x. Composite laterals.
c. Composite centrals.
cd. Cardinal ridge.
F. Foramen.
P. Pedicle-groove.
S. Sipho.

KEYSERLINGIA, Pander.

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Keyserlingia Buchi, Verneuil.

Fig. 1. The interior of a pedicle-valve; showing the depressed or broadly grooved cardinal area, perforated by the opening of a sipho which is blind at its inner termination.

Fig. 2. The interior of a brachial valve; showing a blind internal tube, which is represented as broken, the cavity appearing in cross section.

Fig. 3. The exterior of the pedicle-valve; showing the slit-shaped opening of the pedicle-passage.

Obolus beds. *River Ischora, Russia.*

The above figures are copies of those given by Pander (Bull. de l'Acad. Imp. des Sciences de St. Petersbourg, vol. iii, p. 46, pl. ii, figs. 1, b, c, a), and represent the peculiar features assigned by him to the genus. The views are considerably enlarged.

HELMERSENIA, Pander.

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Helmersenia, sp. ?

Fig. 4. The interior of a pedicle-valve. The cardinal area is broad and bears a median depression or deltidium, as if for the passage of the pedicle.

Fig. 5. The exterior of a similar valve; showing the apical aperture which, according to Pander, is atrophied and blind.

These figures are also taken from the work of Pander cited above (figs. 2 d and b, respectively), and the fossils are from the same beds as those of Keyserlingia.

IPHIDEA, Billings.

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Iphidea cnf.? ornatella, Linnarsson.

Fig. 6. A pedicle-valve, somewhat imperfect about the anterior margin, but showing the subapical area and the very broad cardinal ridge ("pseudo-deltidium," Billings). × 3.

Fig. 7. Profile of the same; showing the height and curvature of the posterior ridge and its basal elevation. × 3.

Tonto group. *Grand Cañon, Arizona.*

Iphidea bella, Billings.

Fig. 8. A pedicle-valve in which the subapical area is relatively small; showing the prominence of the cardinal ridge and the position of the foramen, which is not altogether distinct in the specimen. The figure is also slightly restored about the edges where the original is somewhat broken. × 3.

Fig. 9. Three-quarter view of the same, giving the elevation of the shell and the size of the cardinal ridge. × 3.

Georgia group. *Georgia, Vermont.*

KUTORGINA, Billings.

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Kutorgina cingulata, Billings.

Fig. 10. The pedicle-valve of an example with a low, scarcely incurved beak. × 2.

Fig. 11. The brachial valve. × 2.

Fig. 12. Profile of a pedicle-valve from which the shell is largely removed; showing the degree of incurvature. × 3.

Fig. 13 A pedicle-valve with a strongly incurved umbo; drawn from an internal cast. × 3.

Fig. 14. Profile of the same. × 3.

Fig. 15. A brachial valve; drawn from a gutta-percha impression of a natural mould of the exterior. Natural size.

Fig. 16. The interior of a brachial valve; showing the radiate ornamentation of the surface and the faint muscular ridges near the beak. × 2.

Fig. 17. A brachial valve in which the cardinal margin is not transverse, as in the other examples figured, but is strongly reëntrant. × 2.

Georgia group. *Swanton, Vermont.*

Kutorgina Latourensis, Matthew.

Fig. 18. A pedicle-valve; drawn from a gutta-percha cast from a natural mould of the exterior. × 6.

Fig. 19. Profile of the same. × 6.

Fig. 20. Cardinal view of the same; showing the open triangular fissure. × 6.

St. John group. *Portland, New Brunswick.*

MESOTRETA, Kutorga.

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Mesotreta tentorium, Kutorga.

Fig. 21. The pedicle-valve; copied from Kutorga's work, Ueber die Brachiopoden-familie der Siphonotretæ, pl. vii, fig. 4c.

Lower Silurian. *Russia.*

SIPHONOTRETA, Verneuil.

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Siphonotreta unguiculata, Verneuil.

Fig. 22. Cardinal portion of the pedicle-valve; showing the inner extension of the sipho, which is apparently atrophied and cæcal.

Fig. 23. A similar portion of another valve in which the sipho is open.
(Kutorga, *op. cit.*, pl. vi, fig. 3, a, b.)

Fig. 24. A portion of the shell near the anterior margin, much enlarged to show the tubular structure, the epidermal layers and the mode of origin of the hollow spines.
(Kutorga, *op. cit.*, pl. vi, fig. 2c.)

Figs. 25, 26. The interior characters of both valves as given by Davidson.
(Geological Magazine, 1877, pl. ii, figs. 9, 11.)

SCHIZAMBON, Walcott.

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Schizambon typicalis, Walcott.

Fig. 27. The interior of a pedicle-valve; showing an oval foramen with the groove or depressed track, and diverging lateral muscular ridges. × 5.

Fig. 28. The exterior of a brachial valve; showing the radiating and concentric striæ. In this specimen the surface appears finely granulose, the granulations probably being the bases of minute spinules like those represented by Mr. Walcott (Palæont. Eureka Dist., pl. i, fig. 3d).

Fig. 29. The interior of a brachial valve; showing the outline of the muscular area and its subdivision by diverging ridges. × 5.

Fig 30. Another interior of a brachial valve, differing from the foregoing in the less conspicuous division of the muscular area. The inner pair of diverging ridges terminate anteriorly in deeply colored, oval areas, which are too strongly elevated in the figure. × 5.

Lower portion of the Pogonip group. *Eureka District, Nevada.*

BRACHIOPODA.

Generic Illustrations

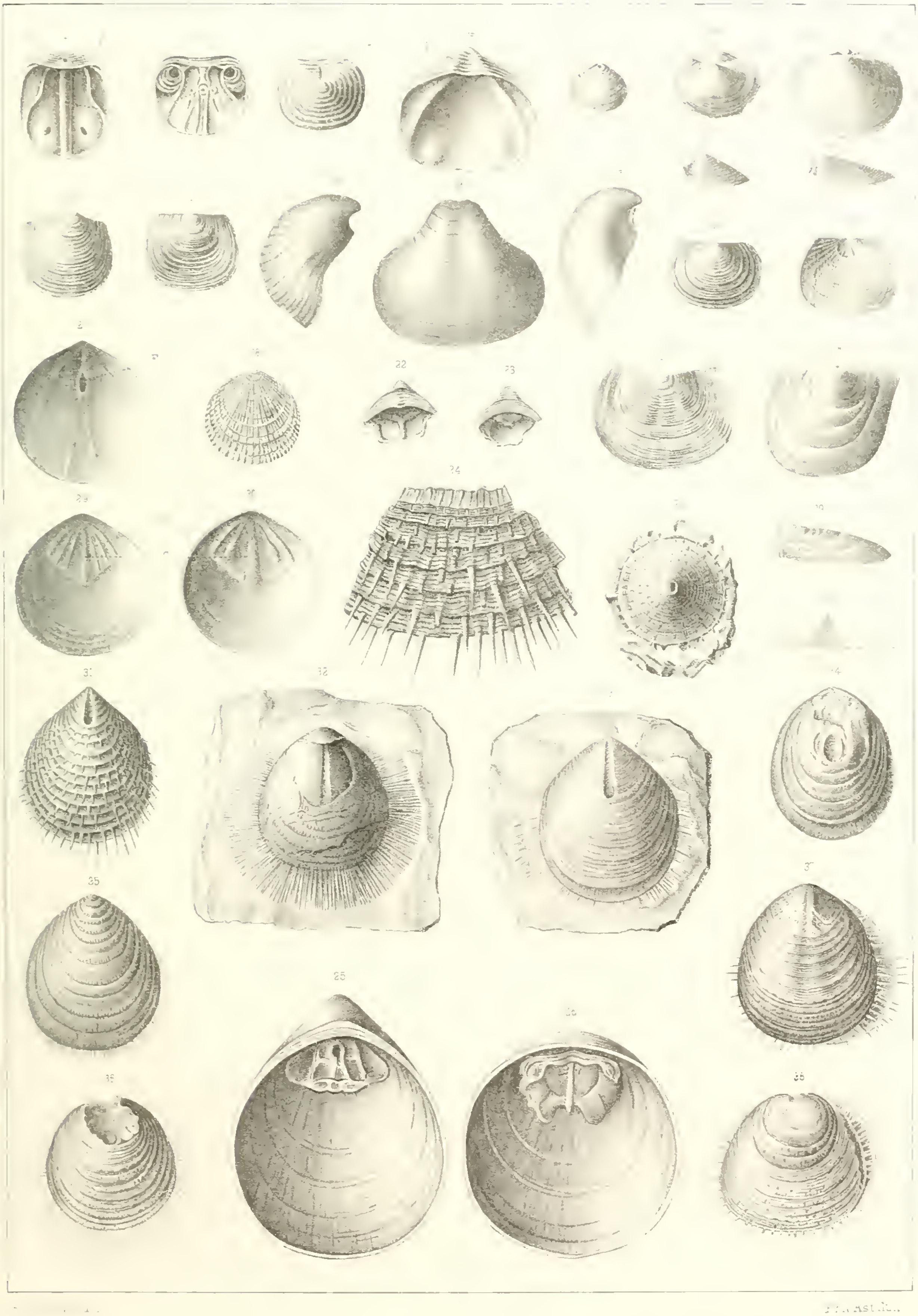

PLATE IV—Continued.

SCHIZAMBON (?) FISSUS, Kutorga.

Fig. 31. A pedicle-valve; showing the external character of the aperture. After KUTORGA, *op. cit.*, pl. vii. fig. 5a'). × 2.5.

SCHIZAMBON (?) FISSUS, var. CANADENSIS. Ami.

Fig. 32. A brachial valve from which the shell is partially broken; showing the impression of an internal median septum. All the spines have been removed except those at and near the margins. These have been pressed together in one plane, giving them the appearance of being more closely set than when standing at their normal angle upon the surface. × 2

Fig. 33. The pedicle-valve; showing the external character of the pedicle-passage. × 2.

Fig. 34. A pedicle-valve from which most of the shell has been broken, giving a cross-section of the sipho near its inner extremity. × 2.

Fig. 35. A brachial valve, the correlate of fig. 34. The surface retains most of the shell, but the spines are broken, showing only their bases, except at the margins where a portion of their length is retained. × 2.

Fig. 36. A pedicle-valve, so broken as to show the inner edge of the sipho.

All the above specimens are from the horizon of the Utica slate. *Near Gloucester, Ontario.*

SIPHONOTRETA (?) MINNESOTENSIS, sp. nov.

Fig. 37. View from the brachial side of a specimen retaining the valves in juxtaposition and preserving most of the epidermal layer of the shell The spine-bases about the beak are noticeably large and more closely set than over the rest of the surface, where they occur at considerable distances along the concentric varices. The entire length of the spines is evidently not represented in the fringe about the margin. × 2.

Fig. 38. The opposite valve of the same specimen. The imperfection of the valve in the umbonal region has rendered it impossible to determine with accuracy the generic character of the species. × 2.

Trenton Limestone. *Minneapolis, Minnesota.*

PLATE IV A.

Legend.
a. Deltidium.
b. Deltidial slope.
c. Deltidial ridges.
d. Areal borders.
i. Umbonal chambers.
j. Platform.
k. Platform-vaults.
m. Median scars.
q. Crown of the crescent.
r. Sides of the crescent.
t. Transverse scars.

TRIMERELLA, Billings.

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Trimerella grandis. Billings.

Fig. 1. An internal cast, viewed from the brachial side; showing the low umbonal chambers, the length of the platform-vaults and the lateral scars of the crescent.

Fig. 2. The reverse of the same specimen; showing the much greater prominence of the umbonal chambers in this valve. The anterior margin and casts of the vaults have been slightly restored in the drawings.

Niagara group. *Near Sinking Spring, Ohio.*

Trimerella Ohioensis, Meek.

Fig. 3. A small pedicle-valve; showing a distortion of the umbo which extends to the posterior portion of the platform. The drawing is made from a gutta-percha impression, and the shell is somewhat restored in the umbonal region.

Niagara group. *Port Byron, Illinois.*

Fig. 4. A brachial valve; showing the incurvature of the beak, the subumbonal ridge merging into the crescent, the broad lateral scars of the crescent, the long, relatively narrow platform with its medially depressed surface, and the strong anterior septum. Drawn from a gutta-percha impression of a natural cast.

Niagara group. *Rising Sun, Ohio.*

Fig. 5. Cardinal view of an internal cast of both valves, the pedicle-valve being above. The posterior margin of the brachial valve shows the impression of the umbo and beneath it a deep depression representing the crescent; the deltidial slope of the pedicle-valve is also visible.

Fig. 6. Brachial view of the same specimen; showing the different lengths of the platform-vaults and the deep umbonal chambers of the opposite valve.

Niagara group. *Genoa, Ohio.*

Fig. 7. View from the brachial side of a specimen retaining the shell; showing also the cardinal area and deltidium of the opposite valve.

Fig. 8. The deltidium and cardinal area, drawn from a gutta-percha impression taken from the specimen represented in figure 9. Slightly enlarged.

Fig. 9. An internal cast of the pedicle-valve of a large individual.

Niagara group. *Ottawa county, Ohio.*

Trimerella Dalli, Davidson and King.

Fig. 10. An internal cast of a pedicle-valve; showing the umbonal chambers, short platform-vaults and indications of the transverse muscular scars.

Guelph limestone. *New Hope, Ontario.*

BRACHIOPODA.

Generic Illustrations.

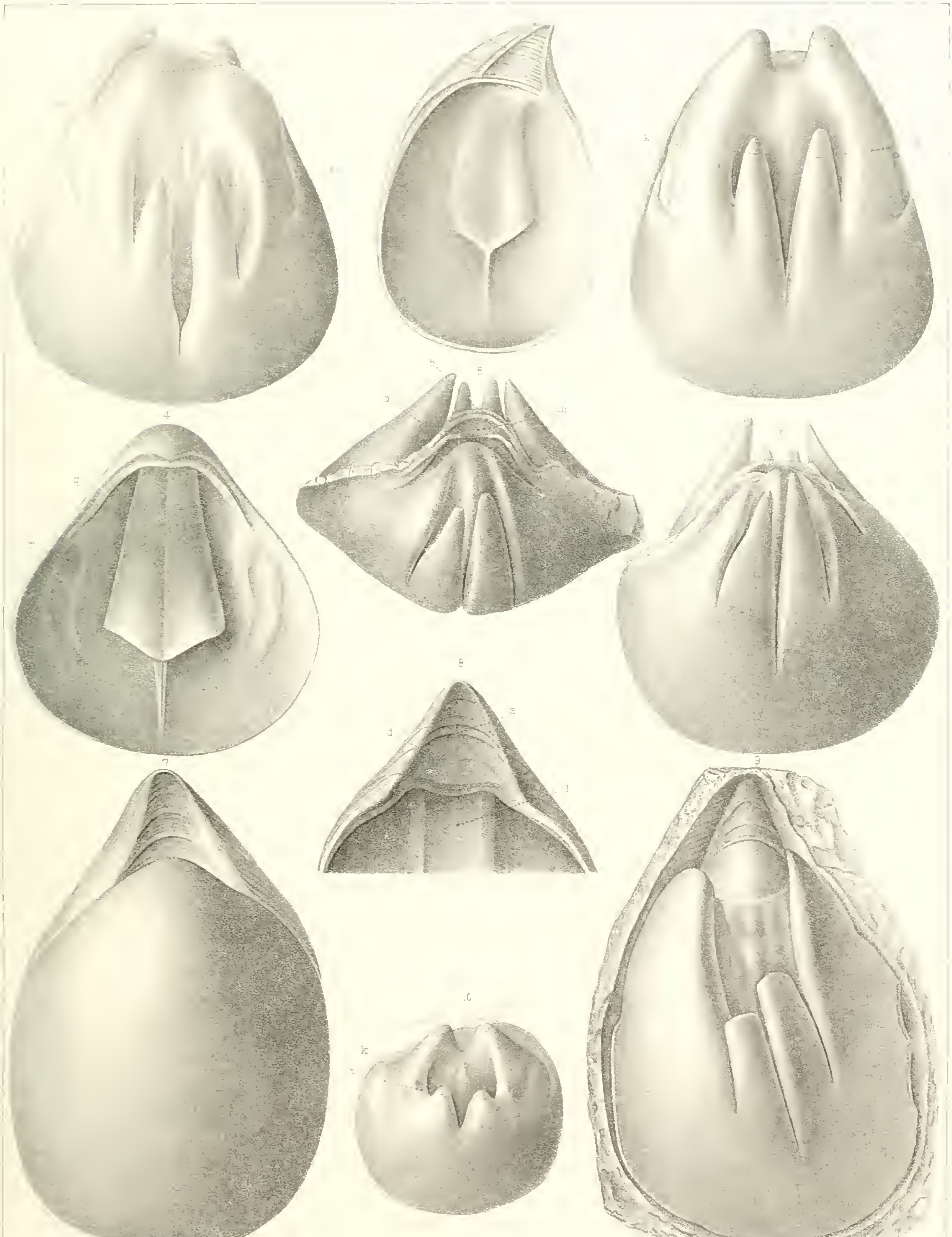

PLATE IV B.

Legend.
a. Deltidium.
b. Deltidial slope.
c. Deltidial ridges.
ca. Cardinal area.
cr. Crescent.
d. Areal borders.
h. Cardinal buttress.
i. Umbonal chambers.
j. Platform.
k. Platform-vaults.
m. Median scars.
n. Anterior scars.
o. Lateral scars.
q. Crown of crescent.
r. Side of crescent.
t. Transeverse scars.
u. Pallial sinuses.
x. Umbo-lateral scars.

TRIMERELLA, Billings.

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Trimerella Lindstrœmi, Dall.

Fig. 1. The interior of an imperfect pedicle-valve; showing the deep excavation at the base of the deltidium in the place usually occupied by the cardinal buttress.

Aymestry limestone. *Island of Gotland.*

Trimerella grandis, Billings.

Fig. 2. An internal cast of a portion of a small pedicle-valve.

Fig. 3. The opposite side of the same.

Guelph limestone. *Galt, Ontario.*

Figs. 4, 5. Transverse sections, showing the structure of the platform.

Trimerella acuminata, Billings.

Fig. 6. The interior of a pedicle-valve, somewhat restored about the umbo; showing the platform, lateral scars of the crescent and the excavate cardinal buttress. From a gutta-percha impression of a natural cast.

Niagara limestone. *Port Byron, Illinois.*

RHINOBOLUS, Hall.

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Rhinobolus Galtensis, Billings.

Fig. 7. The interior of a pedicle-valve; showing the narrow deltidium, broad deltidial ridges and the small, imperfectly developed platform. The drawing is made from a gutta-percha impression of a mould of the interior, the specimen being that originally taken as the type of the genus.

Guelph limestone. *Galt, Ontario.*

Fig. 8. The interior of a small brachial valve.

Guelph limestone. *Elora, Ontario.*

Fig. 9. The interior of a larger brachial valve; drawn from the specimen figured by Whiteaves on plate 8, fig. 3, Palæozoic Fossils, vol. iii, pt. 1.

Guelph limestone. *Hespeler or Durham, Ontario.*

Rhinobolus Davidsoni, sp. nov.

Fig. 10. A small pedicle-valve, showing the internal characters. From a gutta-percha impression of a natural cast.

Fig. 11. The interior of a brachial valve, believed to belong to the same species.

Fig. 12. The interior of a larger brachial valve; showing the undeveloped platform, the crescent and the transverse muscular scars.

Niagara limestone. *Grafton, Wisconsin.*

PLATE IV B—Continued.

DINOBOLUS, Hall.

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Dinobolus Conradi, Hall.

Fig. 13. An internal cast of a brachial valve, indicating very distinctly the muscular impressions and the minute platform-vaults.

Niagara limestone. *Grafton, Wisconsin.*

Fig. 14. An internal cast of a young pedicle-valve; showing the close approximation of the platform-vaults.

Niagara limestone. *Near LeClaire, Iowa.*

Fig. 15. An internal cast of a pedicle-valve; indicating the duplicate platform-vaults.

Niagara limestone. *Racine, Wisconsin.*

Fig. 16. An internal cast of a pedicle-valve in which the vaults of the platform attained unusual length.

Fig. 17. The counterpart of the same; from a gutta-percha impression.

Niagara limestone. *Near LeClaire, Iowa.*

Fig. 18. A transverse section of a shell near the anterior edge of the platform.

Fig. 19. An internal cast of the pedicle-valve, retaining very distinctly the median and lateral muscular scars and the impression of the crescent.

Fig. 20. The counterpart of the same, from a gutta-percha impression; showing the usual size and character of the deltidium.

Niagara limestone. *LeClaire, Iowa.*

Fig. 21. The interior of a pedicle-valve, having the deltidium extremely developed. From a gutta-percha impression of a natural cast.

Niagara limestone. *Near LeClaire, Iowa.*

Fig. 22 An internal cast of a brachial valve, the umbonal cavity of which has been filled by thickening of the shell.

Niagara limestone. *LeClaire, Iowa.*

Fig. 23. An internal cast of a large brachial valve, with the muscular impressions sharply defined.

Niagara limestone. *Racine, Wisconsin.*

Fig. 24. An internal cast of a brachial valve; showing the unsymmetrical development of the vaults of platform, two on one side and three on the other.

Niagara limestone. *LeClaire, Iowa.*

BRACHIOPODA.

Generic Illustrations

E. Emmons del.

Phil. Ast lith.

PLATE IV c.

Legend.

a. Deltidium.
b. Deltidial slope.
c. Deltidial ridges.
ca. Cardinal area.
cg. Cardinal groove.
cr. Crescent.
d. Areal borders.
h. Cardinal buttress.
i. Umbonal chambers.
j. Platform.
k. Platform-vaults.
m. Median scars.
n. Anterior scars.
o. Lateral scars.
q. Crown of crescent.
r. Side of crescent.
u. Pallial trunks.
u'. Secondary pallial sinuses.

MONOMERELLA, Billings.

Page 40.

Monomerella Newberryi, Hall and Whitfield.

Fig. 1. An internal cast of the brachial valve, indicating a strong crescent and low umbonal chambers.

Fig. 2. The reverse of the same specimen; showing the short umbonal chambers and the deep cardinal groove.

Niagara limestone. *Genoa, Ohio.*

Monomerella (cf. orbicularis, Billings).

Fig. 3. Profile view of an internal cast.

Fig. 4. Another view of the same specimen; showing the internal features of the pedicle-valve. The cardinal groove and the crescent are very conspicuous, the umbonal chambers short, scarcely reaching the hinge, and the lateral muscular impressions very sharply developed.

Fig. 5. The opposite side of the same specimen; showing the low umbonal chamber, the strong crescent, and incipient platform-vaults.

Niagara limestone. *Between Grafton and Cedarburg, Wisconsin.*

Monomerella prisca, Billings.

Fig. 6. An internal cast of a portion of the pedicle-valve, in which the cardinal area is very high and the platform slightly unsymmetrical.

Fig. 7. The interior of a pedicle-valve, drawn from a gutta-percha impression of the specimen represented in fig. 6, and slightly restored about the anterior portion.

Fig. 8. The interior of a pedicle-valve in which the deltidium is narrow and elevated, the deltidial ridges obscure, and the areal borders smooth. From a gutta-percha impression of a natural cast.

Fig. 9. An internal cast of a pedicle-valve, in which the umbonal chambers have their usual length. The crescent and lateral scars of the platform are unusually distinct.

Fig. 10. An internal cast of the pedicle-valve, in which the umbonal chambers are of unequal length.

Fig. 11. An internal cast of both valves, to which a portion of the matrix adheres; showing the thickness of the shell in the umbonal regions.

Fig. 12. An internal cast of a brachial valve, with indistinct radiating, probably vascular furrows in the anterior region.

Fig. 13. An internal cast of a brachial valve; showing the characteristic markings of the shell.

Niagara limestone. *Hawthorne, Illinois.*

Monomerella Ortoni, sp. nov.

Fig. 14. An internal cast of the pedicle-valve, in which all the characters of the shell are very sharply defined.

Fig. 15. The counterpart of the same valve, from a gutta-percha impression; showing the broad deltidium without evidence of subdivision, the conspicuous cardinal slope and groove, the crescent and platform scars and the pallial trunks with their ramifications.

Niagara limestone. *Rising Sun, Ohio.*

PLATE IV C—Continued.

MONOMERELLA EGANI, sp. nov.

Fig. 16. A brachial valve; showing the strongly developed cardinal area, the narrow crescent and the platform scars. The umbonal cavity is filled by a thick deposit of testaceous matter.
Niagara limestone. *Grafton, Wisconsin.*

MONOMERELLA OVATA, var. LATA, Whiteaves.

Fig. 17. The brachial side of an internal cast, believed to belong to this variety. The umbonal cavity is broad but well defined, the crescent and platform scars strongly developed. The three diverging furrows in front of the platform are probably to be regarded as vascular markings.

Fig. 18 The opposite side of the same specimen; showing the very short umbonal chambers.
Niagara limestone. *Hawthorne, Illinois.*

BRACHIOPODA

Generic Illustrations

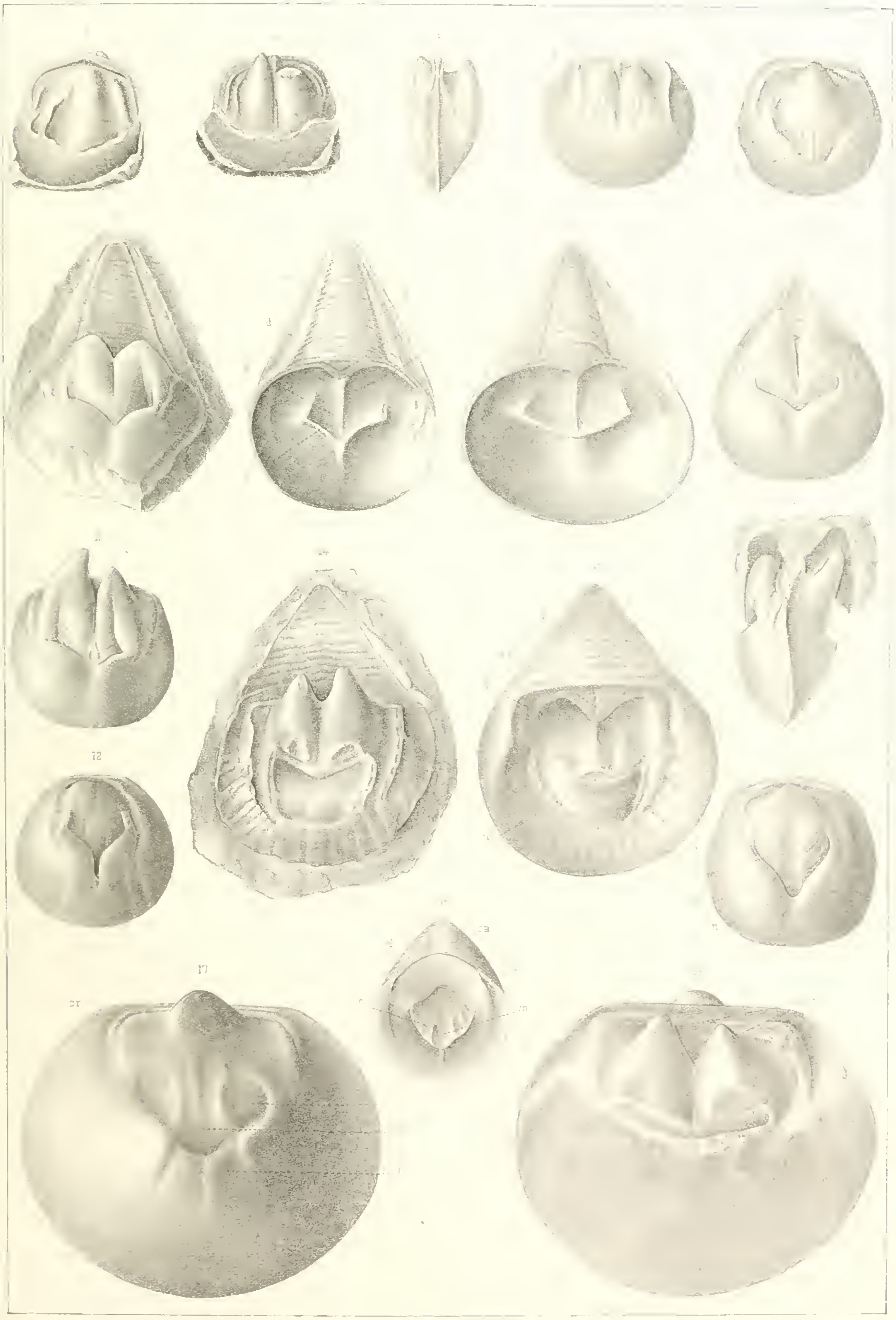

PLATE IV D.

Legend. a. Deltidium.
b. Deltidial slope.
cc. Cardinal area.
cg. Cardinal groove.
cr. Crescent.
d. Areal borders.
i. Umbonal chambers.
j. Platform.
m. Median scars.
n. Anterior scars.
o. Lateral scars.
p. Postmedian scars.
q. Crown of crescent.
r. Side of crescent.
u. Pallial sinuses or ridges (?).

MONOMERELLA, Billings.

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Monomerella Kingi, sp. nov.

Fig. 1. An internal cast of a pedicle-valve; showing the very short umbonal chambers and the sharply defined muscular impressions.

Fig. 2 The opposite side of the same specimen; showing the internal characters of the brachial-valve.

Niagara limestone. *Hawthorne, Illinois.*

Monomerella, sp.?

Fig. 3. The inner side of a specimen retaining the shell, believed to be a brachial valve of some species of this genus. This specimen is considered by Whiteaves as the pedicle-valve of *Rhinobolus Galtensis*. Billings. Should Mr. Whiteaves' opinion prove correct, it will probably be necessary to remove Billings' species to some other genus.

Fig. 4. The exterior of the same specimen.

Guelph limestone. *Galt, Ontario.*

Monomerella Greenii, sp. nov.

Fig. 5. An internal cast of a pedicle-valve; showing the extremely small umbonal chambers and the sharply defined crescent, cardinal groove and lateral scars.

Niagara limestone. *Grafton, Wisconsin.*

Fig. 6. An interior cast of the brachial valve; showing a portion of the broad area of contact, the platform scars, with the diverging anterior ridges.

Niagara limestone. *Rising Sun, Ohio.*

Fig. 7. The interior of a brachial valve, from a gutta-percha cast of a natural impression. The crescentic fulcrum is exceedingly strong and the platform very obscure.

Fig. 8. An internal cast of a pedicle-valve; showing the very broad cardinal margin and its lateral extension; also the faint umbonal cavities and the conspicuous cardinal groove and crescent.

Fig. 9. The interior of a brachial valve, with sharply defined terminal scars and anterior ridges. From a gutta-percha cast.

Fig. 10. An internal cast of a brachial valve; showing, in the matrix, the impression of the cardinal area. The platform scars are accompanied by scarcely any thickening of the shell.

Niagara limestone. *Grafton, Wisconsin.*

Monomerella ovata, var. lata, Whiteaves.

Fig. 11. The exterior of a pedicle-valve. From the original specimen figured by Whiteaves (Palæozoic Fossils, vol. iii, pt. 1, pl. 2, fig. 2*a*).

Fig. 12. A portion of the interior of a pedicle-valve. From Whiteaves' original (*op. cit.*, pl. 8, fig. 2).

Guelph limestone. *Durham, Ontario.*

Monomerella ovata, Whiteaves.

Fig. 13. View from the brachial side of a fine specimen retaining the valves in conjunction.

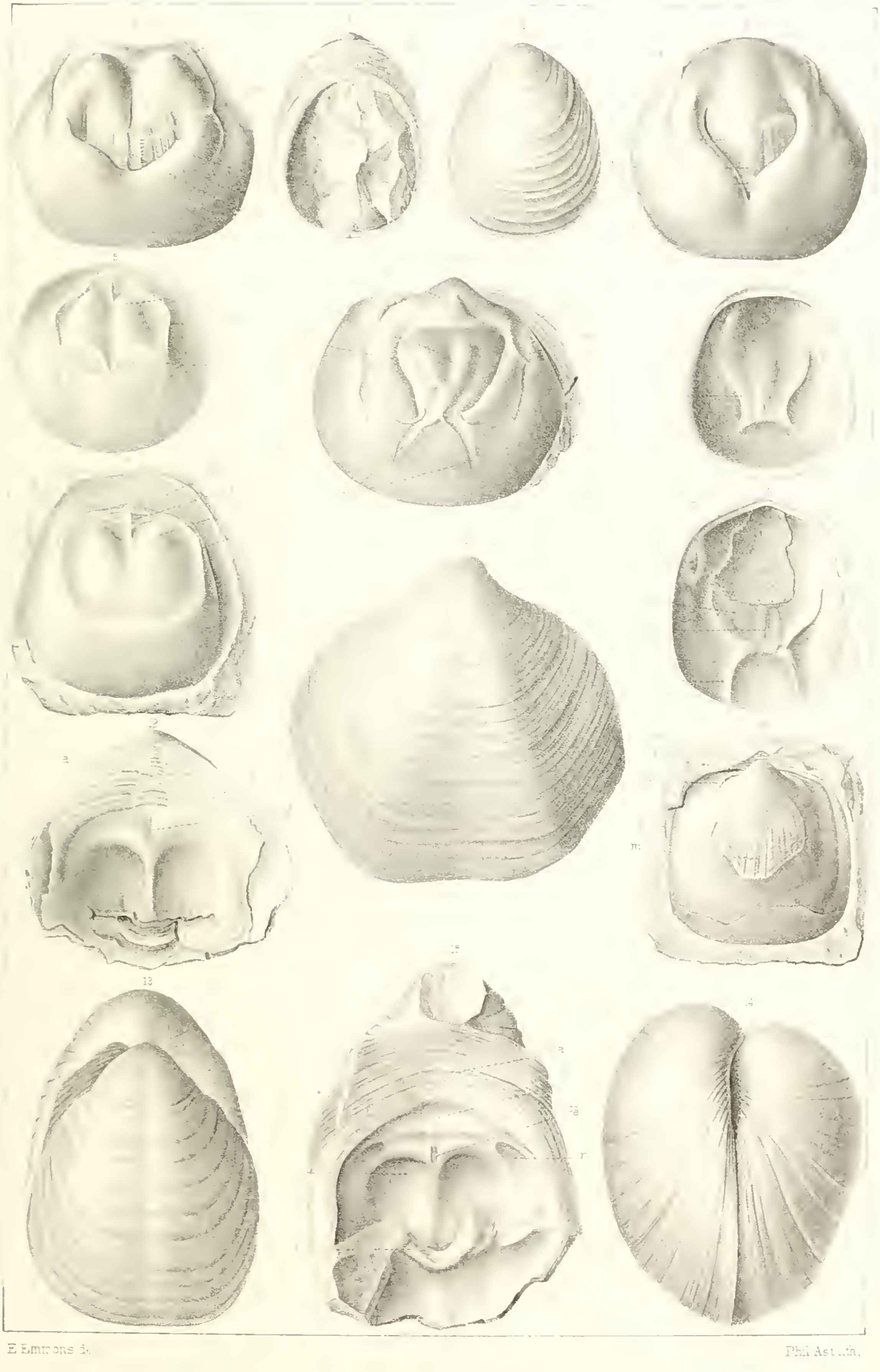
Fig. 14. Profile of the same. From Whiteaves' original specimen (*op. cit.*, pl. 8, figs. 1, 1*a*).

Fig. 15. The interior of a pedicle-valve; showing the broad cardinal area and deltidial slope, the shallow umbonal chambers, the deep cardinal groove and lateral scars of the crescent, and the slightly elevated anterior edge of the platform. From Whiteaves' original specimen (*op. cit.* pl. 8, fig. 16).

Guelph limestone. *Durham, Ontario.*

BRACHIOPODA.

Generic Illustrations



E. Emmons del.

Phil. Ast. lith.

PLATE IV E.

Legend. F. Foramen.
p. Pedicle-area.
g. External pedicle-groove.
g′. The corresponding internal elevation.
aa. Anterior adductor scars.
pa. Posterior adductor scars.
re. Retractor scars.
t. Lateral scars.
ar. Anterior muscular ridges.

DISCINISCA, DALL.

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DISCINISCA LAMELLOSA, Broderip.

Fig. 1. The exterior of a pedicle-valve; showing the broad, depressed pedicle-area, and the oval, direct perforation.

Fig. 2. The interior of the same specimen; showing the characters of the pedicle-area, of which an enlarged view is given on Plate IV F.
Recent. *Peru.*

Fig. 3. The interior of a brachial valve; showing the muscular impressions. After DAVIDSON. (Trans. Linn. Soc., Ser. 2, Zoöl., vol. iv, pl. 26, fig. 4. 1888.)

SCHIZOTRETA, KUTORGA.

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ORBICULOIDEA (SCHIZOTRETA) OVALIS, sp. nov.

Fig. 4. A pedicle-valve from which the shell has been partially broken; showing the short foraminal groove. × 3.

Fig. 5. Profile view of the same specimen; showing the convexity of the conjoined valves. × 3.
Trenton limestone. *Middleville, N. Y.*

SCHIZOTRETA CONICA, Dwight.

Fig. 6. The interior of a brachial valve; showing its extreme shallowness and also indicating the position of the anterior adductor scars. × 2. From the original specimen figured by DWIGHT (Amer. Journ. Science, vol. xix, pl. xxi, fig. 11. 1880).

Fig. 7. An imperfect pedicle-valve: showing the great elevation of the apex and the short foraminal groove. × 2. From the original specimen, *op. cit.*, fig. 3.
Trenton limestone. *Newburgh, N. Y.*

Fig. 8. Outline profile of the conjoined valves. After DWIGHT.

ORBICULOIDEA (SCHIZOTRETA ?) TENUILAMELLATA, Hall.

Fig. 9. The exterior of a brachial valve; showing the elevated somewhat lamellose growth-lines. × 2.
Niagara group. *Western New York.*

Fig. 10. The exterior of a pedicle-valve.

Fig. 11. Profile of the same. (This is the *Discina clara* of SPENCER, = *D. solitaria*, Ringueberg.)
Niagara limestone. *Hamilton, Ontario.*

ORBICULOIDEA, D'ORBIGNY.

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ORBICULOIDEA LAMELLOSA, Hall.

Fig. 12. The exterior of a brachial valve. × 2.
Trenton limestone. *Middleville, N. Y.*

ORBICULOIDEA DISCUS, Hall.

Fig. 13. The interior of a pedicle-valve; showing the elevated and much calloused walls of foraminal passage, and the opening at its posterior extremity.
Lower Helderberg group. *Near Clarksville, N. Y.*

ORBICULOIDEA NUMULUS, sp. nov.

Fig. 14. The exterior of a pedicle-valve.
Lower Helderberg group (Waterlime). *Marshall, N. Y.*

ORBICULOIDEA MEDIA, Hall.

Fig. 15. A brachial valve.
Hamilton group. *Seneca county, N. Y.*

Fig. 16. A pedicle-valve.
Chemung group. *Troupsburg, N. Y.*

Fig. 17. The interior of a pedicle-valve, retaining the shell over the posterior segment only, but showing the elevated pedicle-area and the perforation at its distal extremity.
Hamilton group. *Ontario county, N. Y.*

ORBICULOIDEA RANDALLI, Hall.

Fig. 18. The exterior of a pedicle-valve; showing, from compression, the apical muscular ridge, the radiating pallial sinuses and the internal track of the pedicle-furrow extending toward the margin and interrupting the concentric growth-lines. The overlapping marginal portion of the opposite valve is seen about the posterior arc of the circumference. Natural size.
Hamilton group. *Near Schoharie, N. Y.*

OBICULOIDEA PULCHRA, sp. nov.

Fig. 19. The exterior of a pedicle-valve. × 1.5.
Cuyahoga shale. *Berea, Ohio.*

ORBICULOIDEA MANHATTANENSIS, Meek and Hayden.

Fig. 20. The interior of a pedicle-valve; showing the character of the pedicle-area, the radiating vascular lines, and where the shell is broken on the anterior portion, the character of the external ornamentation and the unusual thickness of the valve.
Coal Measures. *Riley county, Kansas.*

ŒHLERTELLA, S.-GEN. NOV.

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ŒHLERTELLA PLEURITES, Meek.

Fig. 21. The interior of a pedicle-valve; showing the elevated pedicle-ridge and the open, marginal foramen. Natural size.

Fig. 22. Profile of the same, giving the internal elevation of the pedicle-area.

Figs. 23, 24. Brachial valves, differing slightly in outline, and showing the posterior position of the apex.
Waverly group. *Newark, Ohio.*

LINDSTRŒMELLA, S.-GEN. NOV.

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LINDSTRŒMELLA ASPIDIUM, sp. nov.

Fig. 25. A brachial valve, from which the shell is largely exfoliated, but retaining sufficient to show the distinct, elevated, concentric ridges characterizing the external surface. The great lateral ridges and the fainter median septum are represented by furrows. At the posterior extremities of the former are seen two small subcircular muscular impressions, while the scars of the anterior adductors are strongly developed. Natural size.

Fig. 26. The counterpart of the same; drawn from a gutta-percha impression, showing all the internal characters in their natural relief.
Hamilton group. *Near Hamilton, N. Y.*

Fig. 27. A natural cast of the exterior of a large pedicle-valve believed to belong to this species; showing the character of the surface ornamentation, and the peculiar undulation of the concentric ridges on approaching the pedicle-area. The pedicle-passage differs from that in the normal mature ORBICULOIDEA, in not being closed, though its margins appear to be in contact. The characters of this area as represented in the drawing, have been slightly restored from other specimens.
Hamilton group. *Near Leonardsville, N. Y.*

Fig. 28. A small pedicle-valve, with the characteristic ornamentation and strongly developed foraminal groove.
Hamilton group. *Near Darien, N. Y.*

RŒMERELLA, S.-GEN. NOV.

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RŒMERELLA GRANDIS, Vanuxem.

Fig. 29. The exterior of a brachial valve.
Hamilton limestone. *Falls of the Ohio.*

Fig. 30. The interior of a pedicle-valve from which the shell has been partially exfoliated, exposing the matrix and the cast of the external pedicle-groove.

Fig. 31. The counterpart of the same specimen, from a gutta-percha cast; showing all the essential external characters. The extreme depression of the anterior portion of the valve and the correspondingly great elevation of the pedicle-area are features subject to some slight variation within the limits of the species.
Hamilton group. *Cazenovia, N. Y.*

BRACHIOPODA.

Generic Illustrations

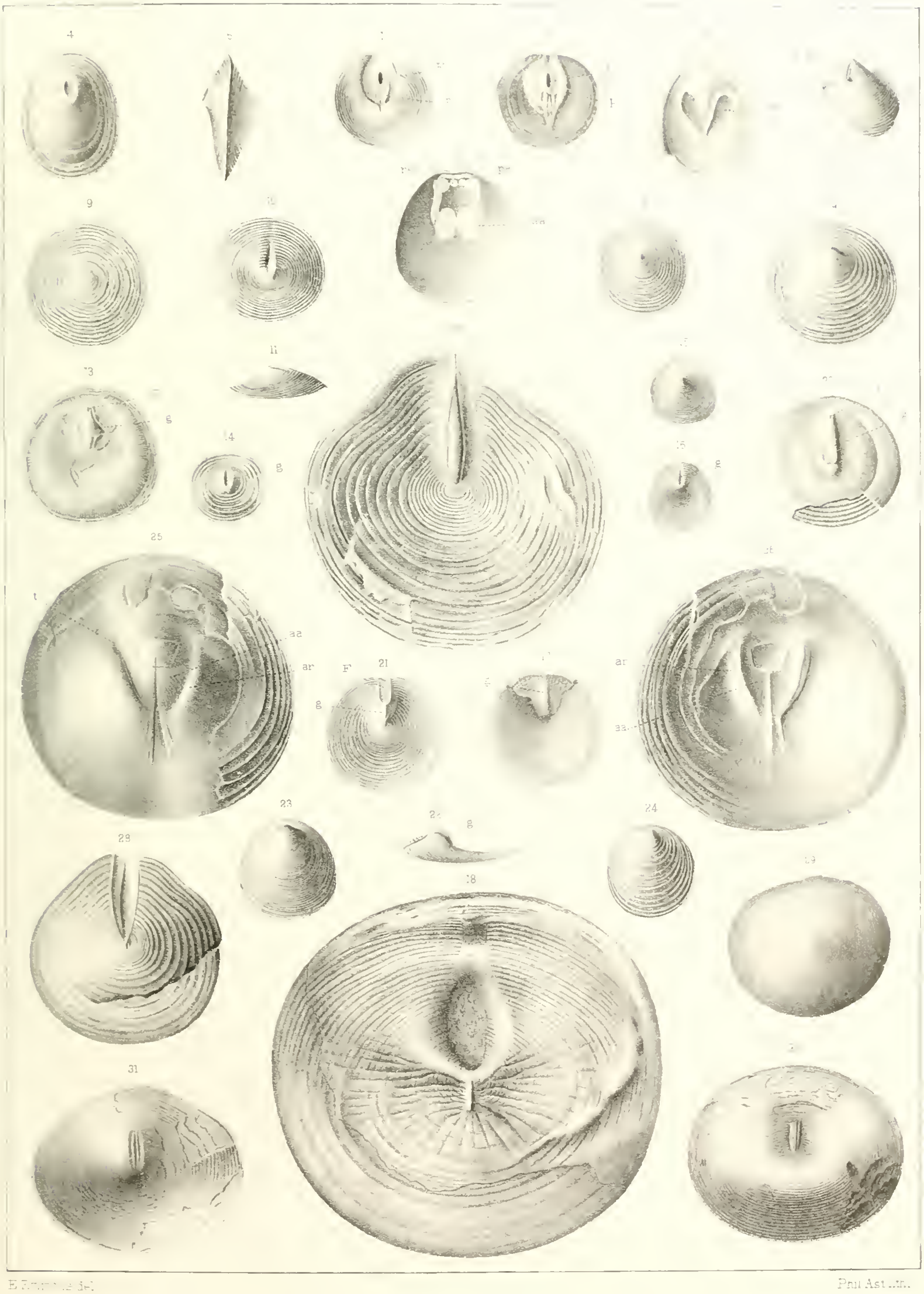

PLATE IV F.

Legend. F. Foramen.
p. Pedicle-area.
p'. Areal callosity.
g. Base of the external pedicle-groove.
g'. Base of the internal pedicle-groove.
l. Lateral walls of the groove.
ar. Anterior muscular ridges.
s. Median septum.
v. Vascular sinuses.

DISCINISCA, Dall.

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Discinisca lamellosa. Broderip.

Fig. 1. The internal pedicle-area, enlarged to three diameters from the specimen represented in Plate IV E, fig. 2. The pedicle-area is a somewhat thickened elevation, corresponding to the deep depression on the external surface of the valve. The foramen transects the area directly, and between it and the posterior margin is a narrow translucent lamina, across which the concentric ornamentation of the valve does not pass.

SCHIZOTRETA, Kutorga

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Orbiculoidea (Schizotreta ?) tenuilamellata, Hall.

Fig. 2. The exterior pedicle-area of a specimen in which the groove is extremely short. × 5.

Fig. 3. A similar view of a specimen in which the groove is relatively larger, and the base, walls and foramen well defined. × 5.

Fig. 4. The corresponding parts in another specimen. × 5.

Fig. 5. The groove of the same; showing that the concentric growth-lines are retained on the broad lateral walls, while the base is smooth though less distinctly defined than in some instances. × 16.

Fig. 6. The pedicle-characters of the interior, drawn from a natural cast of the exterior, in which, from the compression of the shell, the internal characters are preserved in continuity with those of the outside.

Niagara limestone *Hamilton, Ontario.*

Schizotreta conica. Dwight.

Fig. 7. The external characters of the pedicle-area; from the specimen represented in Plate IV E, fig. 7. × 3.

ORBICULOIDEA. D'Orbigny.

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Orbiculoidea pulchra, sp. nov.

Fig. 8. The internal pedicle-area. The elevated median ridge corresponding to the base of the external groove, is slightly broken, a crack extending to the foramen. About the anterior moiety of the ridge the lateral callosities have just begun to form. × 3.

Fig. 9. The same, in a more advanced stage of development. The callosities have increased to such a degree as to have almost come into contact for the entire length of the area, leaving the position of the internal ridge indicated by the groove between their edges. × 3.

Cuyahoga shales. *Berea, Ohio.*

Fig. 10. The same parts, still showing a remnant of the groove formed by the meeting of the lateral callosities; also indicating the position of the foraminal opening. × 3.

Cuyahoga shales. *Baconsberg, Ohio.*

Figs. 11, 12. The same features, from individuals in which the lateral callosities have coalesced, leaving the foramen open, but otherwise concealing the structure of the area. × 3.

Fig. 13. The interior of the apical portion of the brachial valve; showing the small median septum, extending forward from the apex. × 3.

Cuyahoga shales. *Berea, Ohio.*

Fig. 30. An internal cast of a brachial valve; showing the impressions of two strong, diverging vascular sinuses (?) and finer markings about the margin. × 1.5.

Cuyahoga shales. *Newark, Ohio.*

Fig. 32. A very young pedicle-valve, with a length of 2.25 mm., having the posterior margins of the aperture unclosed, while the pedicle-groove has nearly its entire normal length. × 12.

Cuyahoga shales. *Berea, Ohio.*

Orbiculoidea, compare O. pulchra.

Figs. 14, 15, 16. The internal characters of the pedicle-area; showing the envelopment of the ridge by the lateral callosities, in various stages of advancement. × 3.

Waverly group. *Meadville, Pa.*

Orbiculoidea marginalis, Whitfield.

Fig. 17. The internal characters of the pedicle-area. The callosities have assumed an irregular, but bilaterally symmetrical form, almost enveloping the pedicle-ridge. × 3

Hamilton group. *Centreville, Wis.*

ORBICULOIDEA NEWBERRYI, Hall.

Fig. 18. The same features; showing the strong elevation of the area, but the absence of callosities, the large foramen, the sharply defined, though flattened median ridge and lateral walls of the pedicle-passage. × 3.

Waverly group. *Cuyahoga Falls, Ohio.*

(From the original locality, a ferruginous band about 110 feet below the conglomerate.)

ŒHLERTELLA S.-GEN NOV.

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ŒHLERTELLA PLEURITES, Meek.

Fig. 19. The internal characters of the pedicle-area; showing the open marginal foramen, the elevated, radially striated lateral walls, the median ridge and a short apical septum. × 3.

Fig. 20. The same features from another specimen, in which the walls of the area are smooth and the apical septum absent. × 3.

Waverly group. *Newark, Ohio.*

ORBICULOIDEA, D'ORBIGNY.

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ORBICULOIDEA LODENSIS, Vanuxem.

Fig. 21. The internal characters of the pedicle-area; indicating the unusual breadth and depth of the base of the groove and the low lateral walls; also the interruption in the ornamention of the shell from the foramen outwards, probably indicating the line of union of the primitive margins of the aperture. × 4.

Genesee shale. *Lodi, N. Y.*

ORBICULOIDEA, sp. indet.

Fig. 22. A natural cast of the interior apical portion of the brachial valve; showing the anterior and posterior muscular ridges. × 3

Chemung group. *Warren, Pa.*

ORBICULOIDEA NITIDA, Phillips.

Fig. 23. The pedicle-area of an extremely young shell, having a diameter of 1 mm. The foramen is a marginal slit extending, with divergent edges, for almost the entire radius of the valve. At the apex, the pedicle-groove appears in an incipient stage. × 50.

Fig. 24. A considerably later stage of development of these parts, the diameter of the shell being 5 mm.; showing the margins of the foramen united for most of their length, but still separated at the posterior edge of the valve. The structure of the area is somewhat obscured by the compression of the specimen. × 12.

Fig. 25. A later stage of growth, exhibited by a specimen 7 mm. in diameter. Here the angles made by the edges of the foramen with the posterior edge of the shell are acute and approximate. The pedicle-groove has progressed so as nearly to fill the entire hiatus. × 7

Figures 23–25 are from a block of black shale upon which valves of this species are crowded in great numbers, to the exclusion of other fossils. The condition of the pedicle-area in its later development, as shown in the following figures, is also amply represented in these specimens.

Lower Coal Measures *Springfield, Illinois.*

Fig. 26. The internal pedicle-area of a small but mature individual; showing the base and lateral walls of the groove and the slight callosity at the apical extremity. × 7.

Fig. 27. The external surface of a similar specimen; showing the general form of the groove at maturity, and the absence of any furrow or interruption of the concentric ornamentation beyond its posterior extremity. × 7.

Fig. 28. The entire valve, of which fig. 27 represents the pedicle-area. × 2.

Coal Measures. *Grover, Missouri.*

Fig. 29. The interior of a pedicle-valve; showing the base of the groove, the foramen and the muscular impressions. (After DAVIDSON. Brit. Carb. Brach., Suppl., pl. xxx, fig. 13 *a*.)

ORBICULOIDEA, sp., Meek.

Fig. 31. "An impression of the outside of the under valve in the matrix (slightly less than natural size), with portions of the thin shell adhering, so as to show the smooth inside, and a prominent internal ridge, corresponding to a deep external furrow, with a small, round or oval foramen at its outer end." (MEEK, Palæontology of Eastern Nebraska, plate iv, fig. 3, and Explanation.)

Coal Measures. *Near Nebraska City, Neb.*

BRACHIOPODA.

Genera Illustrated.

E. Emmons Jr.

Phil. Ast. ...

PLATE IV G.

Legend.	B.	Brachial valve.
	P.	Pedicle-valve.
	F.	Foramen.
	p.	Pedicle-callosity (in brachial valve).
	g.	Pedicle-groove.
	g′.	Base of groove.
	l.	Walls of groove.
	s.	Median septum.
	o.	Posterior muscular scars.
	c.	Central scars.
	pc.	Posterior centrals.
	cc.	Median centrals.
	ac.	Anterior centrals.
	pa.	Posterior adductors.
	pa′.	Anterior element of posterior adductors.
	aa.	Anterior adductors.

TREMATIS, Sharpe.

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Trematis terminalis, Emmons.

Fig. 1. The interior of a brachial valve; showing the posterior and central muscular scars and the linguiform median elevation. × 3.

Fig. 2. An internal cast of the pedicle-valve; showing the great depression of the pedicle-area, the median ridge corresponding to the pedicle-groove, and the vascular sinuses. × 3.
Trenton limestone. *Middleville, N. Y.*

Trematis, sp., compare T. punctostriata, Hall.

Fig. 3. The internal pedicle-area; showing the elevation of the margins of the fissure. × 4.
Hudson River group. *Frankfort, Ky.*

Trematis millipunctata, Hall.

Fig. 4. The interior of a brachial valve; showing the posterior callosity forming a surface for the passage of the pedicle, the external muscular scars and the components of the central impressions. × 2.
Hudson River group. *Covington, Ky.*

Fig. 5. An internal cast of a brachial valve, to which a portion of the shell adheres. × 2.

Fig. 6. The exterior of a brachial valve, from which the shell is partially exfoliated. × 2.

Fig. 7. Profile of an internal cast of the conjoined valves.

Fig. 8. Anterior view of the same specimen, exposing the pedicle-valve and the projecting apical portion of the brachial valve. × 2.
Hudson River group. *Cincinnati, Ohio.*

Fig. 9. The interior of a brachial valve; showing the posterior muscular scars beneath the broken pedicle-callosity. × 1.5.
Hudson River group. *Frankfort, Ky.*

Fig. 10. The external ornamentation. × 25.

Trematis punctostriata, Hall.

Fig. 11. The exterior of a brachial valve. × 2.

Fig. 12. The interior of a pedicle-valve. × 2.

Fig. 13. The external ornamentation. × 25.
Trenton limestone. *Clifton, Tenn.*

Trematis fragilis, Ulrich.

Fig. 14. A pedicle-valve; showing the short and narrow pedicle-fissure.
Hudson River group. *Bank Lick Creek, Ky.*

Trematis Ottawensis, Billings.

Fig. 15. External view of a brachial valve. From a gutta-percha cast of the exterior. Natural size.

Fig. 16. The surface ornamentation. × 25.
Trenton horizon. *Frankfort, Ky.*

Fig. 17. The external pedicle-area, from a specimen referred with doubt to this species. × 3.
Hudson River group. *Cincinnati, Ohio.*

Trematis umbonata, Ulrich.

Fig. 18. The exterior of the brachial valve. × 2.

Fig. 19. The same specimen, with the upper portion of the brachial valve removed, exposing the flat lower valve and its pedicle-fissure. × 2.
From the original specimen figured by Ulrich (American Geologist, vol. iii. No. 6, p. 378, fig. 8, 1889). Hudson River group. *Covington, Ky.*

PLATE IV G—Continued.

Trematis oblata, Ulrich.

Fig. 20. The brachial valve, retaining a portion of the external ornamentation. × 2.
From a gutta-percha cast of the original specimen (*op. cit.*, fig. 19).
Hudson River group. *Cincinnati, Ohio.*

SCHIZOCRANIA, Hall and Whitfield.

Page 112.

Schizocrania (?) rudis, Hall.

Fig. 21. The exterior of the brachial valve. × 2.
Trenton limestone. *Clifton, Tenn.*

Schizocrania filosa, Hall.

Fig. 22. The exterior of a brachial valve, attached to *Strophomena alternata*. × 2.
Hudson River group. *Cincinnati, Ohio.*

Fig. 23. The exterior of a large brachial valve.

Fig. 24. The pedicle-valve.
Utica slate. *Mohawk Valley, N. Y.*

Fig. 25. A valve of *Strophomena alternata*, to which five of these shells are attached, all of them exposing the lower valve.

The figure is taken from the Palæontology of Ohio, vol. ii, pl. i, fig. 12, and the muscular scars on the internal cast of the upper valve, shown in the left of the illustration, remain as there represented.

Fig. 26. An internal cast of the brachial valve; showing the elongate, converging posterior scars, separated into posterior and anterior elements; also a faint median ridge extending forward beyond the muscular impressions. × 3.

Fig. 27. The pedicle-valve seen on the right margin of fig. 25; showing the apical pedicle-callosity or incipient groove. × 2.

Palæontology of Ohio, vol. ii, pl. i, fig. 15.

Fig. 28. The pedicle-area viewed from within; showing more accurately the character of the apical callosity, its median ridge and lateral walls indicating homology with the corresponding parts in the genus Orbiculoidea × 3.
Hudson River group. *Cincinnati, Ohio.*

Fig. 29. An individual from which the upper portion of the brachial valve has been removed, exposing all the internal characters of the pedicle-valve. × 2.

It will be observed that in this figure, as well as in figs. 25, 33, 34 and 35, the diameter of the lower valve is less than that of the upper, and the former lies above and within the base of the latter, the attachment of the shell being largely effected by the marginal portions of the larger valve.
Hudson River group. *Covington, Ky.*

Fig. 30. An internal cast of a brachial valve; showing the anterior and posterior muscular scars. The former impressions are rarely discernible. × 1.5.
Trenton limestone. *Trenton Falls, N. Y.*

Schizocrania Schucherti, sp. nov.

Fig. 31. A brachial valve, retaining a portion of the external ornamentation, but showing the posterior muscular scars. × 3.

Fig. 32. A smaller brachial valve, retaining most of the exterior surface. × 3.

Fig. 33. An individual from which most of the upper valve has been removed, exposing the pedicle-valve. The features of the pedicle-area are not so clearly retained as to allow delineation. × 3.
Hudson River group. *Covington, Ky.*

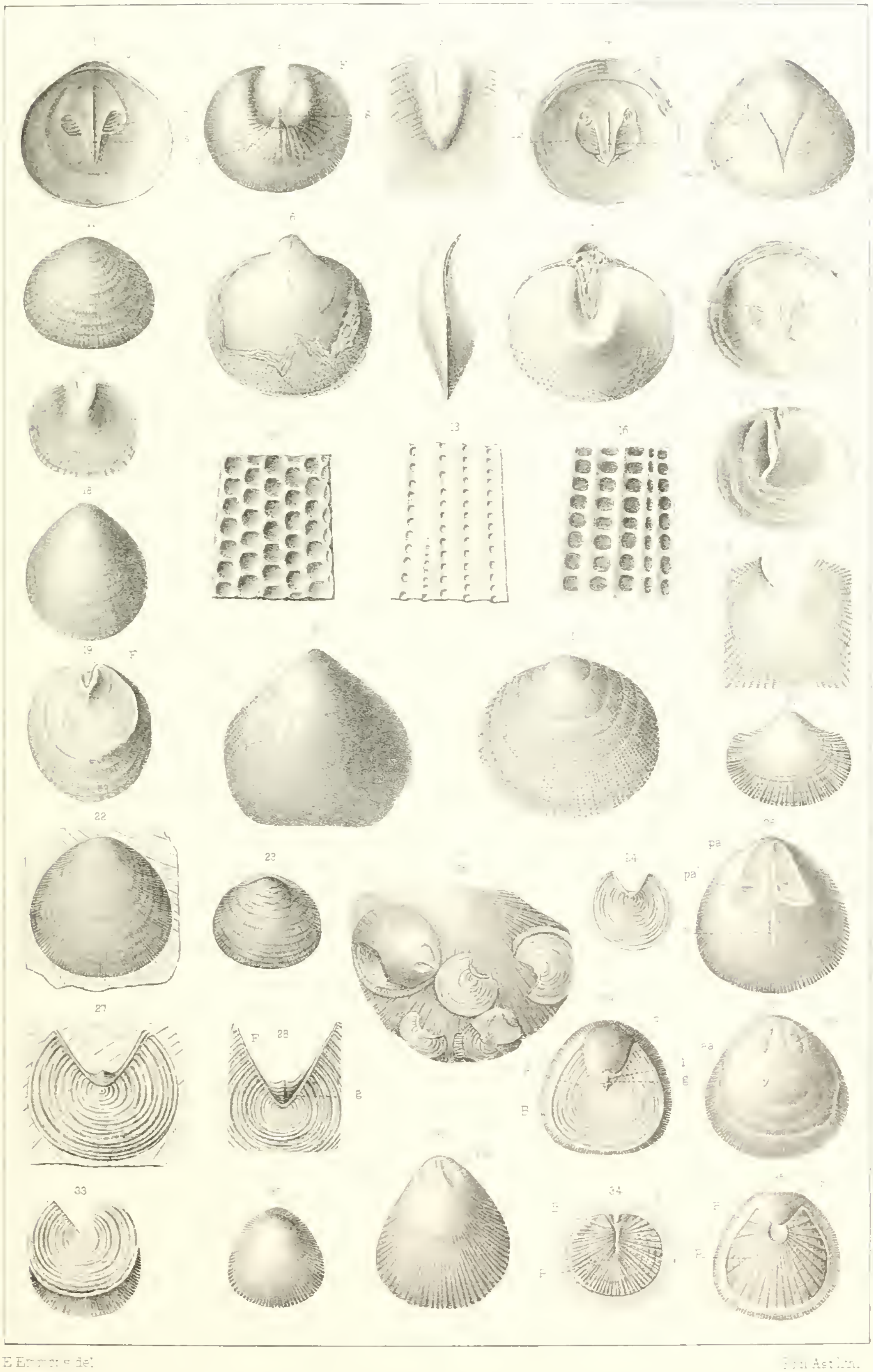
Schizocrania (?) Helderbergia, sp. nov.

Fig. 34. The exterior surface of an individual; showing the pedicle-valve, its coarsely radiate and obscure concentric striation, and the overlapping edges of the finely striated upper valve. The character of the pedicle-aperture is not well retained. × 2.

Fig. 35. The internal surface of the pedicle-valve; showing what appears to be a broad pedicle-fissure, and the overlapping margins of the upper valve. × 3.
Lower Helderberg group. *Near Clarksville, N. Y.*

BRACHIOPODA.

Generic Illustrations



E Emmons del

Ast lith.

PLATE IV ii.

Legend. pa. Posterior adductor scars.
aa. Anterior adductor scars.
b. Brachial muscular scars.
m. Median muscular fulcrum.
v. Vascular sinuses.

CRANIA, Retzius.

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Crania Lælia, Hall.

Fig. 1. Four individuals attached to the pedicle-valve of *Streptorhynchus planumbonum.*
Hudson River group. *Oxford, Ohio.*

Crania agaricina, sp. nov.

Fig. 2. An individual attached to a branch of Trematopora; showing the characteristic sparse and relatively coarse radiating ribs. × 3.
Lower Helderberg group. *Near Clarksville, N. Y.*

Crania pulchella, sp. nov.

Fig. 3. An individual attached to the valve of *Orthis subcarinata.* It differs from the preceding species in its finer, more numerous ribs and greater size. × 2
Lower Helderberg group. *Near Clarksville, N. Y.*

Crania Bordeni, Hall and Whitfield.

Fig. 4. An individual attached to a valve of *Spirifer Oweni;* showing the very fine radiating striæ, and the conformation of the upper valve to the surface of attachment.
Fig. 5. Profile of the same specimen.
Hamilton limestone. *Clarke county, Indiana*

Crania crenistriata, Hall.

Fig. 6. The interior of an upper valve; showing the strong anterior adductor scars and very faint posterior adductors. × 2.
Hamilton limestone. *Falls of the Ohio.*
Fig. 7. A portion of a cast of the internal surface in a decomposed chert; showing the filling of vertical canals. × 25.
Corniferous limestone. *Canandaigua, N. Y.*
Fig. 8. The interior of an upper valve; showing the very strong anterior adductor scars with margins elevated, and the more obscure posterior scars. × 3.
Hamilton limestone. *Falls of the Ohio.*
Fig. 9. The exterior of a large upper valve. Natural size.
Hamilton group. *Canandaigua Lake, N. Y.*
Fig. 10. A smaller uncompressed individual.
Fig. 11. Profile of the same.
Hamilton group. *Western New York.*
Fig. 12. A valve of the same, or a closely allied species, attached to *Orthis impressa.* × 5.
Upper Devonian. *Rockford, Iowa.*

Crania Rowleyi, Gurley.

Fig. 13. An individual showing the upper valve. × 2.
Choteau limestone. *Pike county, Missouri.*

Crania setigera, Hall.

Fig. 14. An individual, referred to this species with some hesitation; attached to a branch of Monticulipora. It will be observed that for some distance about the anterior edges of the shell, where the valves opened for the admission of food-bearing water-currents, the outward growth of the bryozoan cells has been obstructed. × 2.
Trenton horizon *Minneapolis, Minnesota.*
Fig. 15. An upper valve. × 2.
Fig. 16. Profile of the same. × 2.
Trenton limestone. *Mineral Point, Wisconsin.*

Crania spinigera, Hall.

Fig. 17. The original specimen; an individual attached to the shell of *Rhynchonella Stricklandi.* The ornamentation consists of radiating rows of sharply defined tubercles. × 3.
Niagara group *Waldron, Indiana.*

CRANIA SETIFERA, Hall.

Fig. 18. A somewhat imperfect upper valve.
Niagara group. *Waldron, Indiana.*

CRANIA GRANOSA, sp. nov.

Fig. 19. A somewhat distorted upper valve; showing the finely granulose surface.
Fig. 20. A portion of the surface enlarged. × 20.
Hamilton group. *Centerfield, N. Y.*

CRANIA TRENTONENSIS, Hall.

Figs. 21, 22. Front and profile views of an upper valve.
Trenton limestone. *Middleville, N. Y.*

CRANIA SCABIOSA, Hall.

Fig. 23. A brachial valve of *Strophomena alternata*, covered with shells of this species all of which carry the radiating and fine concentric ornamentation of the host.

Fig. 24. The interior of an upper valve, the external surface of which is overgrown by a MONTICULIPORA. The posterior adductors are larger than the anterior pair, and near their outer edges the small scars of the adjustors are discernible. In this species as usually preserved the muscular impressions appear as dark discolorations of the shell, indicating a probable greater density of the shell-substance. × 2.

Fig. 25. The interior of a lower valve. The posterior scars are more distant and smaller than in the opposite valve, while the anterior scars are much larger. × 2.

Fig. 26. A shell of *Platystrophia lynx*, having the surface of the brachial valve crowded with individuals of this species.
Hudson River group. *Cincinnati, Ohio.*

CRANIA MULTIPUNCTATA, Miller (= *Crania scabiosa*, Hall).

Fig. 27. One of a group of individuals attached to a fragment of MONTICULIPORA. The punctate surface character of the host is impressed upon the shell, giving it a remote resemblance to the surface of *Trematis terminalis*. × 2.
Hudson River group. *Covington, Ky.*

Fig. 28. Another specimen with similar surface markings. × 2.
Hudson River group. *Blanchester, Ohio.*

CRANIA SOCIALIS, Ulrich (= *Crania scabiosa*, Hall).

Fig. 29. A fragment of a crinoid column, covered with individuals which retain very distinctly the impressions of the sutures between the segments. × 3.
Hudson River group. *Covington, Ky.*

CRANIA PERCARINATA, Ulrich (= *Crania scabiosa*, Hall).

Fig. 30. An individual which has been attached to some species of PLEUROTOMARIA. × 3.
Fig. 31. Another specimen, which also bears the surface markings of some gastropod. × 3.
Hudson River group. *Covington, Ky.*
These figures are from Mr. ULRICH'S typical specimens.

CRANIA. sp. nov.?

Fig. 32. The interior of an upper valve of a probably smooth species. × 2.
Lower Helderberg group. *Near Clarksville, N. Y.*

CRANIA FAVINCOLA, sp. nov.

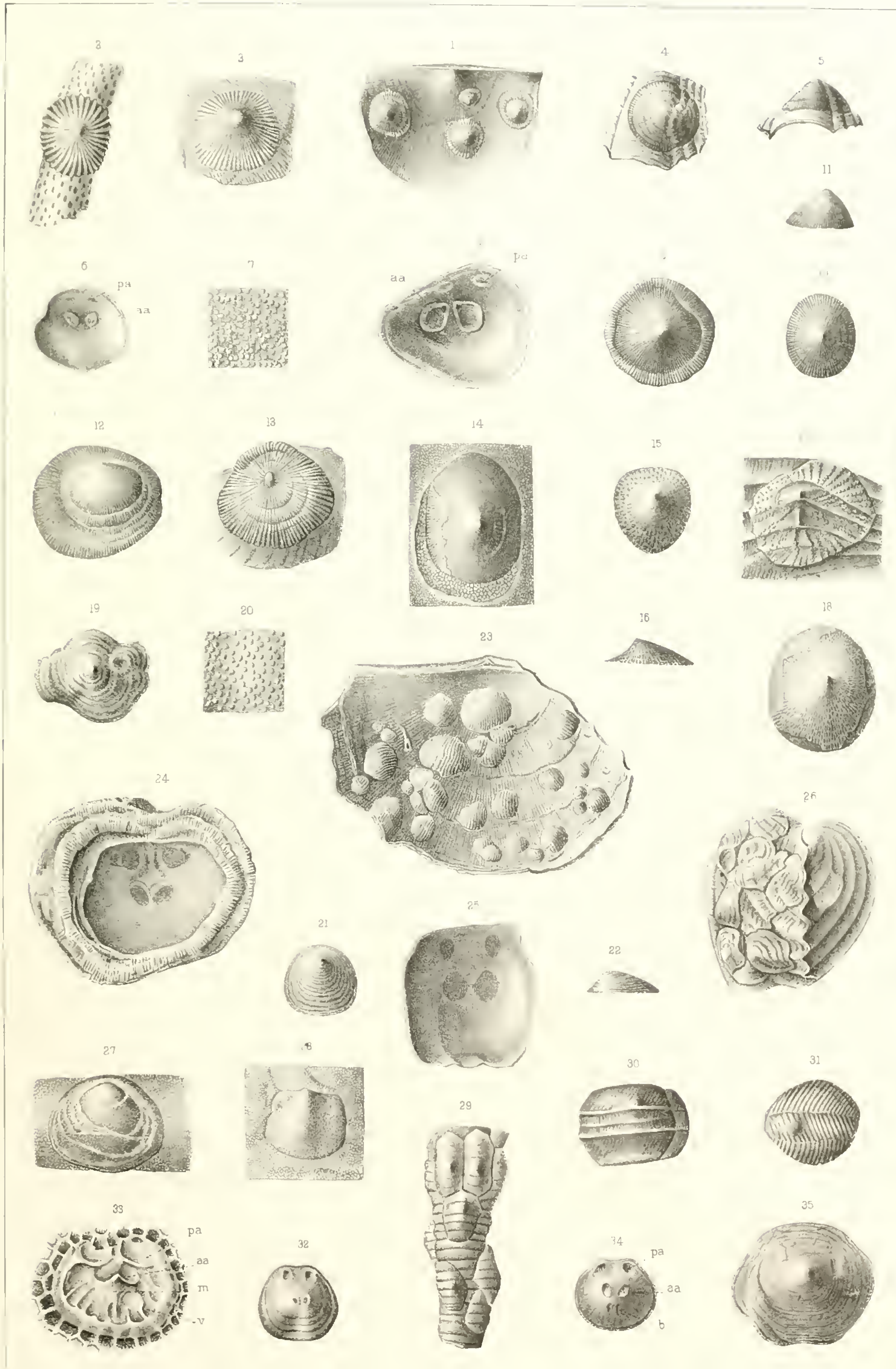
Fig. 33. A lower valve, slightly broken about the posterior margin, but showing the very large posterior muscular impressions, the deeply impressed anteriors, with sharply elevated margins and median fulcrum; also, the radiating pallial sinuses. The shell is attached to a specimen of *Favosites pirum*, Davis.
Hamilton group. *Crab Orchard, Ky.*

CRANIA LEONI, Hall.

Fig. 34. The interior of an upper valve; showing, in addition to the posterior and anterior adductor scars, the faint impressions of the brachial muscles.
Fig. 35. The exterior of an upper valve.
Chemung group. *Leon, N. Y.*

BRACHIOPODA.

Generic Illustrations



E Emmons del

Phil Ast lith.

PLATE IV I.

Legend. pa. Posterior adductors.
aa. Anterior adductors.
da. Dorsal adjustors.
va. Ventral adjustors.
mm. Mesenteric muscular impression.
p. Parietal impression.
m. Median impressions.
b. Brachial muscular impression.
v. Vascular trunks.
v'. Vascular branches.

CRANIELLA, Oehlert.

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Craniella Ulrichi, sp. nov.

Fig. 1. A cast of the interior of a lower valve, somewhat restored on the right side; showing the strong anterior and very obscure posterior adductor impressions, and the marks of the vascular sinuses. The shell is convex and shows no evidence of attachment, though the external surface is overgrown with a bryozoan. Drawn from a gutta-percha cast of a natural interior. × 1.5.
Trenton limestone. *Minneapolis, Minnesota.*

Fig. 2. The internal cast of an upper valve, believed to be of the same species. The sigmoid vascular impressions are simpler than elsewhere observed; the scars of the dorsal adjustors and of muscles accessory to the anterior adductors (possibly the brachial muscles) are also apparent. Drawn from a gutta-percha cast of a natural interior. × 1.5.
Trenton limestone. *Minneapolis, Minnesota.*

Craniella Hamiltoniæ, Hall.

Fig. 3. The interior of a lower valve attached to a Streptelasma; showing the usual character of the muscular scars, viz, anterior and posterior adductors, the ventral adjustors, and post-median or mesenteric impression; also the characteristic radiating vascular sinuses.
Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 4. The interior of an upper valve.
Corniferous limestone. *Falls of the Ohio.*

Fig. 5. The interior of an attached valve. From Palæontology of New York, vol. iv, pl. iii, fig. 23.

Fig. 6. Three individuals of different sizes, attached to the surface of *Tropidoleptus carinatus. Opero citato*, pl. iii, fig. 19.
Hamilton group. *Western New York.*

Fig. 7. The interior of a lower valve; showing the usual muscular and vascular impressions, and very great thickening of the shell. × 2.

Fig. 8. An upper valve; showing the modification of the surface from attachment to an individual of *Spirifer audaculus.*

Fig. 9. Profile view of a normal shell, attached to *Tropidoleptus carinatus.*
Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 10. The exterior of an upper valve. From Thirteenth Rept. State Cab. Nat. Hist., p. 76, fig. 3. 1860.
Hamilton group. *Western New York.*

Fig. 11. An upper valve, modified by attachment to the post-lateral portion of a right valve of *Cypricardella (Microdon) bellistriata.*
Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 12. An individual greatly modified by attachment to *Tropidoleptus carinatus.*

Fig. 13. An internal cast of a large upper valve; showing the usual muscular scars and the peculiar sigmoid vascular trunks with their ramifications.
Hamilton group. *Pratt's Falls, N. Y.*

Fig. 14. An internal cast of a very convex upper valve, greatly modified by attachment. × 2.
Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 15. An internal cast of an upper valve; showing the characteristic impressions. × 2.
Hamilton group. *Bellona, N. Y.*

Fig. 16. An internal cast of a convex and apparently free lower valve; showing the closer approximation of the anterior and posterior adductor scars than in the opposite valve, the deep impresssion of the mesenteric muscle, and the radiating vascular sinuses. The figure is slightly restored on the left side. × 2.
Hamilton group. *Centerfield, N. Y.*

PHOLIDOPS, Hall.

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Pholidops Trentonensis, Hall.

Fig. 17. A slightly crushed specimen. × 4.
Trenton limestone. *Middleville, N. Y.*

Pholidops Cincinnatensis, Hall.

Fig. 18. The exterior of a normal specimen. × 4
Hudson River group. *Cincinnati, Ohio.*

PHOLIDOPS SUBTRUNCATA, Hall.

Fig. 19. The exterior of an individual; showing the slightly flattened posterior slope and faint median angulation. × 4.
Hudson River group. *Lorraine, N. Y.*

PHOLIDOPS OVALIS, Hall.

Fig. 20. The external surface; showing the characteristic outline and subcentral apex. × 6.
Niagara group. *Waldron, Indiana.*

PHOLIDOPS SQUAMIFORMIS, Hall.

Fig. 21. The interior of a large ventral (?) valve; showing the character of the muscular area, the median, anterior adductor, lobed posterior adductor, and parietal impressions. × 5.
Niagara group. *Hamilton, Ontario.*

PHOLIDOPS OVATA, Hall.

Fig. 22. An internal cast of a dorsal (?) valve; showing the sharply defined anterior and posterior adductors, and the parietal scar. × 6.
Fig. 23. The interior of the opposite valve; showing the relatively small size of the muscular area. × 6.
Lower Helderberg group. *Near Clarksville, N. Y.*

PHOLIDOPS ARENARIA, Hall.

Fig. 24. An internal cast of a dorsal (?) valve. From the original specimen. × 2.
Oriskany sandstone. *Knox, N. Y.*

PHOLIDOPS AREOLATA, Hall.

Fig. 25. An internal cast of the ventral (?) valve. × 3.
Schoharie grit. *Near Clarksville, N. Y.*
Fig. 26. An internal cast of the opposite valve. × 3.
Schoharie grit. *Knox, N. Y.*

PHOLIDOPS PATINA, sp. nov.

Fig. 27. The exterior of a valve; showing the lamellose growth-lines, crossed by fine, interrupted, radiating striæ. Drawn from a gutta-percha cast of a natural mould in decomposed chert. × 4.
Fig. 28. The interior of a dorsal (?) valve. From a gutta-percha cast. × 4.
Fig. 29. The interior of the opposite valve. × 4.
Corniferous limestone. *De Cewville, Ontario.*

PHOLIDOPS CALCEOLA, sp. nov.

Fig. 30. The interior of a dorsal (?) valve; showing the terminal beak and subapical area, and the character of the muscular impressions. × 12.
Corniferous limestone. *Falls of the Ohio.*

PHOLIDOPS HAMILTONIÆ, Hall.

Fig. 31. The exterior of the shell. × 4.
Fig. 32. Profile of the same specimen showing the valves in conjunction. × 4.
Hamilton group. *Western New York.*
Fig. 33. The interior of a ventral (?) valve; showing the character of the muscular impressions. × 8.
Fig. 34. The interior of the opposite valve; showing the muscular and parietal scars. × 4.
Hamilton group. *Canandaigua Lake, N. Y.*

PHOLIDOPS LINGULOIDES, Hall (?).

Fig. 35. The interior of a dorsal (?) valve; showing the terminal and slightly deflected beak, the subapical area, and the character of the muscular scars. × 2.
Hamilton group. *Eighteen Mile Creek, N. Y.*

PHOLIDOPS OBLATA, Hall.

Fig. 36. An internal cast of the dorsal (?) valve, with two deep anterior adductor scars, the posterior adductors being very faintly developed, as in the preceding figure. This and figure 35 may represent the same species. × 4.
Hamilton group. *Carter's Mills, N. Y.*

PHOLIDOPS, compare P. HAMILTONIÆ.

Fig. 37. The exterior of the shell; showing the form and outline. × 6.
Bedford shales. *Bedford, Ohio.*

BRACHIOPODA.

Generic Illustrations

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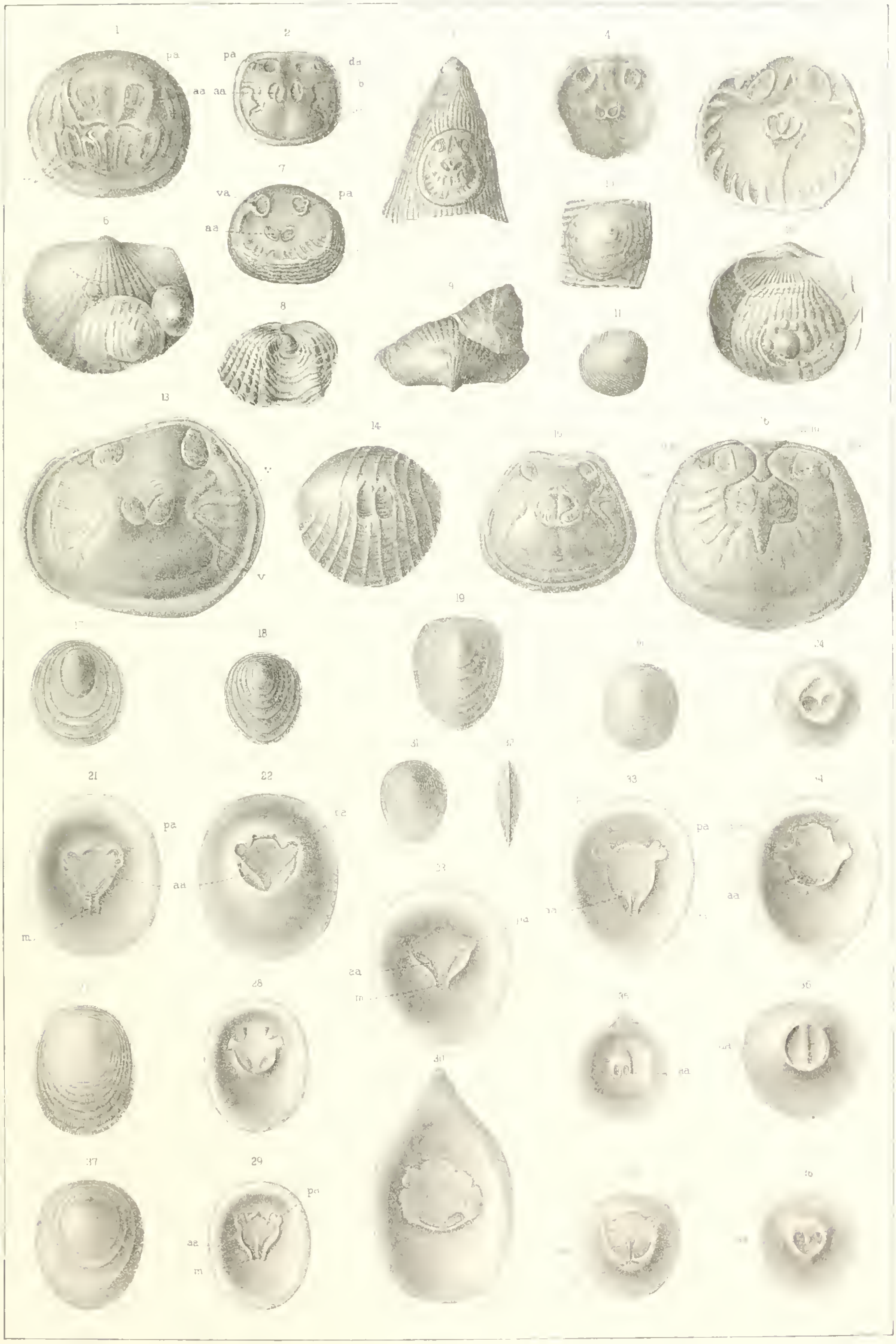
Plate IV



E. Emmons del.

Phil. Ast lith.

PLATE IV K.

PATERULA, Barrande.

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PATERULA (?), sp.

Fig. 1. The interior of a pedicle-valve, taken from a natural cast of the internal surface. The broad marginal border, narrow fissure and radiate muscular markings, indicate the close agreement of this fossil with PATERULA. × 5.

Quebec group. *South St. John's Market, Quebec.*

MONOBOLINA, Salter.

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MONOBOLINA PLUMBEA, Salter.

Fig. 2. Exterior of a brachial (?) valve. × 3.

Fig. 3. Interior of a similar valve. × 3. (DAVIDSON, Brit. Sil. Brach., pl. I, figs. 23, 24.)

ORBICULOIDEA, D'Orbigny.

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ORBICULOIDEA, sp. ?

Fig. 4. The interior of a brachial valve; showing a faint median apical septum and radiating muscular ridges. × 2.

St. Louis limestone. *Crittenden county, Ky.*

LINGULA, Bruguière.

Page 2.

LINGULA LINGUATA, sp. nov.

Fig. 5. The pedicle-valve from which the epidermal layer is partially exfoliated; showing the peculiar deflection of the anterior margin, which is a constant feature. × 2.

Clinton group. *Near Hamilton, Ontario.*

LINGULA, sp. (?).

Fig. 6. An internal cast to which a fragment of the shell adheres. The surface is covered with minute papillæ, which are probably casts of the inner openings of the vertical canals. × 5.

Black slate (Genesee horizon). *Near Vanceburg, Ky.*

LINGULA WAVERLIENSIS, Herrick.

Fig. 7. View from the pedicle-valve, of a specimen retaining the impression of the pedicle.

Waverly sandstone. *Oil City, Penna.*

LINGULA TÆNIOLA, sp. nov. (=*Lingula lamellata*, Hall. Pal. N. Y., vol. ii, p. 55, pl. xx, figs. 4 a, b, c. 1847).

Fig. 8. The pedicle-valve; showing the peculiar surface ornamentation, crossed near the beak by concentric growth-lines. × 1.5.

Clinton group. *Clinton, N. Y.*

LINGULA CUNEATA, Conrad.

Fig. 9. An internal cast of a pedicle-valve; showing the muscular scars and vascular sinuses. × 3.

Medina sandstone. *Medina, N. Y.*

LINGULA LAMELLATA, Hall.

Fig. 10. View from the pedicle-valve of an internal cast, retaining the impression of the lateral and central muscular scars and of the pallial sinuses. The matrix is filled with minute ovoid bodies (*ova*), which appear to be distributed wherever the sinuses and their branches have extended. About the anterior and lateral margins of the valve the matrix is the opaque mud of the sediment; elsewhere the spaces between the ova are translucent. × 3.

Fig. 11. The opposite side of the same specimen; also showing the muscular, vascular and septal impressions. The intermixture of the opaque matrix on this side is somewhat greater than on the other, obliterating the ova to some extent. × 3.

Fig. 12. A thin section of a portion of this specimen, which shows the ovoid bodies to be opaque and homogenous. × 12

Fig. 13. An enlargement of the surface of the cast; showing the appearance of the ova when magnified 12 diameters. The vertical ridges are casts of radiating furrows on the interior of the valve.

Niagara group. *Near Hamilton, Ontario.*

LINGULOPS, Hall.

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LINGULOPS GRANTI, sp. nov.

Fig. 14. The interior of a brachial valve. × 6.

Fig. 15. The interior of a pedicle-valve. The muscular area is here developed into a well-defined platform, while in the other species of the genus, *L. Whitfieldi* and *L. Norwoodi*, it still retains its linguloid character. × 6.

Niagara group. *Hamilton, Ontario.*

CONOTRETA, Walcott.

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CONOTRETA RUSTI, Walcott.

Fig. 16. Anterior view of a pedicle-valve. The apical and anterior regions retain a portion of the shell, but elsewhere the shell is removed, showing the impressions of the internal radiating muscular ridges. × 4.

Fig. 17. An internal cast of a smaller pedicle-valve; showing the impression of the strong apical callosity, and the radiating ridges. × 8.

Fig. 18. An apical view of the same valve; showing the subtriangular posterior slope, and its obscurely defined median furrow. × 9.

Fig. 19. Cardinal view of a very young individual, in which the posterior slope is very faint. × 12.

Trenton limestone. *Trenton Falls, N. Y.*

Fig. 20. Cardinal view of another very small example, retaining the shell.

Fig. 21. Profile of same. × 25

Hudson River group. *Covington, Ky.*

OBOLUS, Eichwald.

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OBOLUS [?] PULCHER, Matthew.

Fig. 22. The exterior of a valve, retaining the shell and showing the character of its ornamentation. × 3.

St. John group. *Caton's Island, New Brunswick.*

DISCINA, Lamarck.

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DISCINA STRIATA, Schumacher.

Fig. 23. The interior of a pedicle-valve.

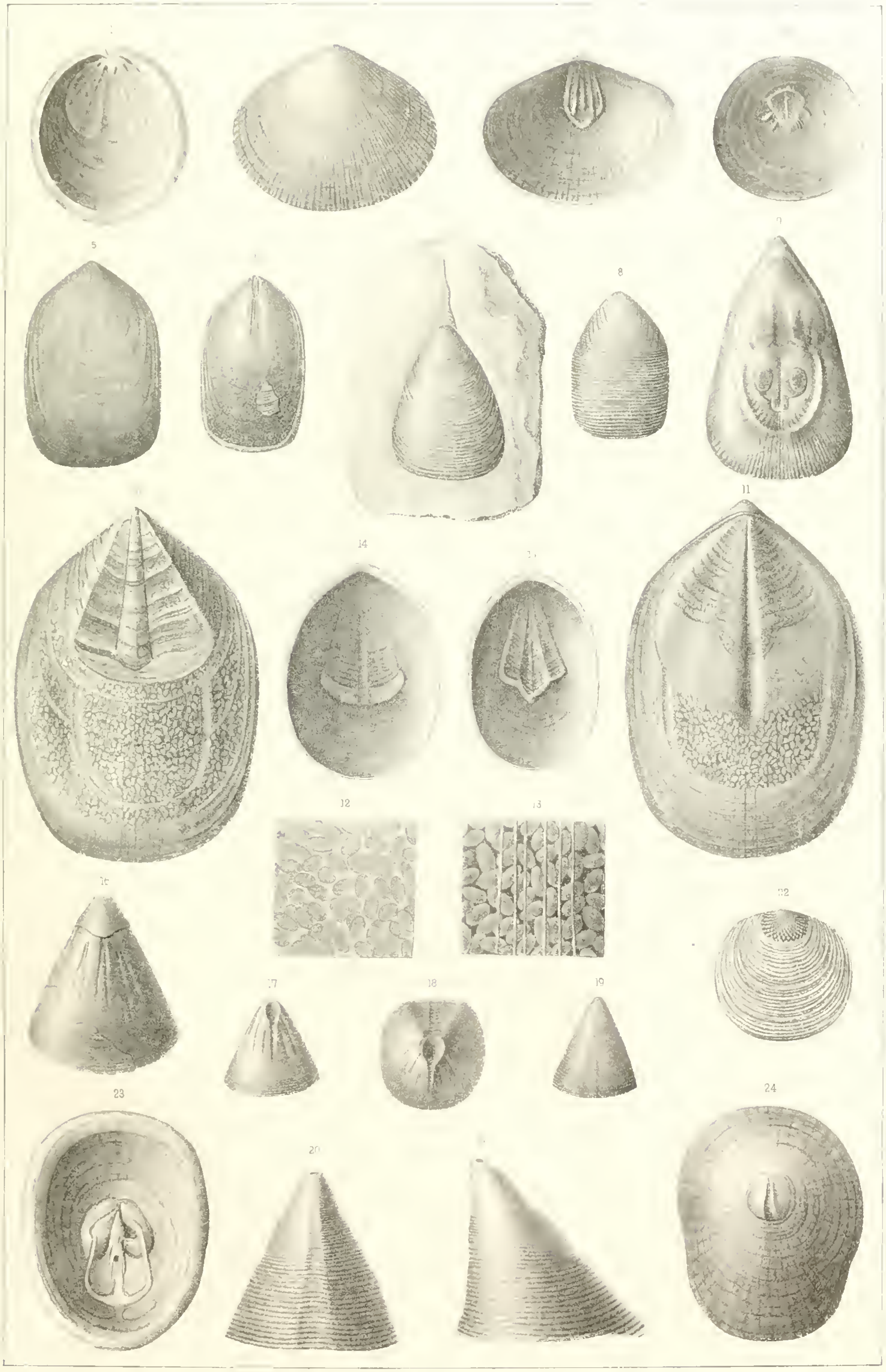
Fig. 24. The exterior of a similar valve. Much enlarged.

Recent. *Cape Palmas.*

(After DAVIDSON. Trans. Linnean Soc., Ser. 2, Zool., vol. iv, pl. 25, figs. 24, 25. 1889.)

BRACHIOPODA.

Generic Illustrations



E. Emmons del. Phil. Ast lith.

PLATE V.

(Figures 1-8, 13, 18-26, 29-36 by E. EMMONS, 9-12, 14-17, 27, 28, 37-41 by R. P. WHITFIELD.)

Legend.
- Δ. Deltidium.
- t. Teeth.
- j. Cardinal process.
- fp. Crural plate.
- a. Anterior adductor impressions.
- a′. Posterior adductor impressions.
- r. Anterior diductor impressions.
- r′. Posterior diductor impressions.
- v. Vascular markings.
- s′. Deltidial plate or callosity.

ORTHIS DALMAN. 1828.

Page 186.

ORTHIS, as restricted.

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"ORTHIS ORTHAMBONITES (Pander)" Billings.*

Figs. 1, 2. Exterior and interior views of a pedicle-valve. × 3.
Fig. 3. Interior of a brachial valve.
From Mr. BILLINGS' original specimens. "*Point Lévis; in the upper part of Limestone No. 2, Quebec group.*"

ORTHIS EURYONE, Billings.

Fig. 4. Exterior of a pedicle-valve; from the original specimen. "*Point Lévis; in the upper part of Limestone No. 2, Quebec group*"

ORTHIS DAVIDSONI, de Verneuil.

Fig. 5 Interior of a pedicle-valve; showing the character of the cardinal and muscular areas.
Fig. 6. Profile of an individual having the valves in conjunction.
Fig. 7. A portion of the exterior of the pedicle-valve; showing the fine transverse striæ and the openings of sparsely scattered, oblique tubu es, which penetrate the outer layers of the shell. × 4.
Fig. 8. A portion of the cardinal area of the brachial valve; showing the linear cardinal process, crural plates, thickened deltidial area and the low median ridge. × 3.
Upper Silurian limestone. *Island of Gotland.*
For further illustration, see DAVIDSON, Silurian Brachiopoda, plate xxxv. figs. 18, 19.

ORTHIS TRICENARIA, Conrad.

Figs. 9-11. Views of the brachial and pedicle-valves and the profile of a specimen with valves conjoined; showing the general exterior characters of this type of structure.
Fig. 12. The interior of a pedicle-valve; showing a slight apical accretion or callosity in the delthyrium, and the muscular area in which the impression of the central adductors is unusually developed.
Trenton horizon. *Mineral Point, Wisconsin.*
Fig. 13. The cardinal area of a pedicle-valve; showing the character of the apical callosity partially filling the delthyrium. × 3.
Trenton horizon. *St. Paul, Minnesota.*
Fig. 14. The interior of a brachial valve; showing the character of the process, crural plates and muscular area.
For further illustration, see Palæontology of New York, Volume I, plate xxxii, fig. 6.

ORTHIS COSTALIS, Hall.

Fig. 15. An internal cast of the pedicle-valve; showing the characters of the muscular area and vascular markings. × 2.
Figs. 16, 17 Outline profile and full view of another pedicle-valve.
Chazy limestone. *Chazy, N. Y.*
For further illustration, see Palæontology of New York, Volume I, plate iv bis. fig. 4.

PLECTORTHIS, NOM. NOV.

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ORTHIS PLICATELLA, Hall.

Fig. 18. A view of the brachial valve of a normal adult, a strongly biconvex shell with a moderately low cardinal area and strong, distant, simple ribs.

* See note on this species on page 221. The American shell differs from the Russian *O. calligramma*, var. *orthambonites*, de Verneuil, in its smaller size, fewer and coarser ribs with fine radial striations, and being thus a quite distinct form, it may receive the designation *Orthis Panderiana*, nom. nov.

Fig. 19. The deltidial portion of the pedicle-valve; showing the broad delthyrium and the outline of the muscular area which is not sufficiently thickened to obscure the plications of the shell. × 3.

Fig. 20. The area in the opposite valve; showing the cardinal process, crural plates and low median ridge. × 3.

Hudson River group. *Covington, Kentucky.*

For further illustration, see Palæontology of Ohio, Volume I, plate viii, fig. 7.

Orthis dichotoma, Hall.

O. dichotoma, Hall, = *O. fissicosta*, Meek, not Hall.

Fig. 21. The interior of the brachial valve; showing the cardinal process, crural plates and the character of the plications.

Hudson River group. *Covington, Kentucky.*

For further illustration, see Palæontology of Ohio, Volume I, plate viii, fig. 6, under the name of *O. fissicosta*.

Orthis Ella, Hall.

Fig. 22. An individual viewed from the brachial valve, showing area and foramen of the opposite valve. × 2.

Fig. 23. A portion of the interior of the pedicle-valve; showing the characters of the cardinal area. × 3.

Hudson River group. *Covington, Kentucky.*

For further illustration, see Palæontology of Ohio, Volume I, plate viii, fig. 9.

Orthis Kankakensis, McChesney.

Figs. 24, 25. Brachial and profile views of a normal individual.

Hudson River group. *Wilmington, Illinois.*

Orthis Whitfieldi, N. H. Winchell.

Fig. 26. The interior of a pedicle-valve; showing the relatively high area and strong teeth, the character of the muscular area, and the low ridges radiating from its anterior margin.

Hudson River group. *Spring Valley, Minnesota.*

DINORTHIS, nom. nov.

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Orthis pectinella (Emmons), Conrad.

Figs. 27, 28. A view of the pedicle-valve, and profile of a specimen in which the ribs are more subdivided toward the margin than is usual in the species. × 2.

Trenton limestone. *Lewis county, New York.*

Fig. 29. The interior of a small pedicle-valve; showing the subquadrate muscular area with the posterior and anterior diductor and the adductor scars.

Trenton horizon. *St. Paul, Minnesota.*

Figs. 30, 31. A view from the pedicle-valve and the profile of a large individual, showing the strongly elevated, simple ribs.

Fig. 32. The interior of a pedicle-valve.

Fig. 33. The cardinal portion of a brachial valve. × 2.

Trenton horizon. *Curdsville, Kentucky.*

For further illustration, see Palæontology of New York, Volume I, plate xxxii, fig. 10.

Orthis Sweeneyi, N. H. Winchell.

Fig. 34. Exterior of the pedicle-valve; showing the depressed-convex shell.

Fig. 35. A profile of conjoined valves; in this figure the pedicle-valve as represented is too convex and too high at the beak.

Fig. 36. The interior of the brachial valve.

Trenton horizon. *St. Paul, Minnesota.*

ORTHIS as restricted.

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Orthis flabellites, Hall.

Figs. 37, 38, 39. The exterior of the pedicle and brachial valves and profile of an average specimen.

Fig. 40. The interior of the pedicle-valve; showing the character of the muscular area.

Fig. 41. The interior of the brachial valve; showing the cardinal process, crural plates and quadripartite muscular area.

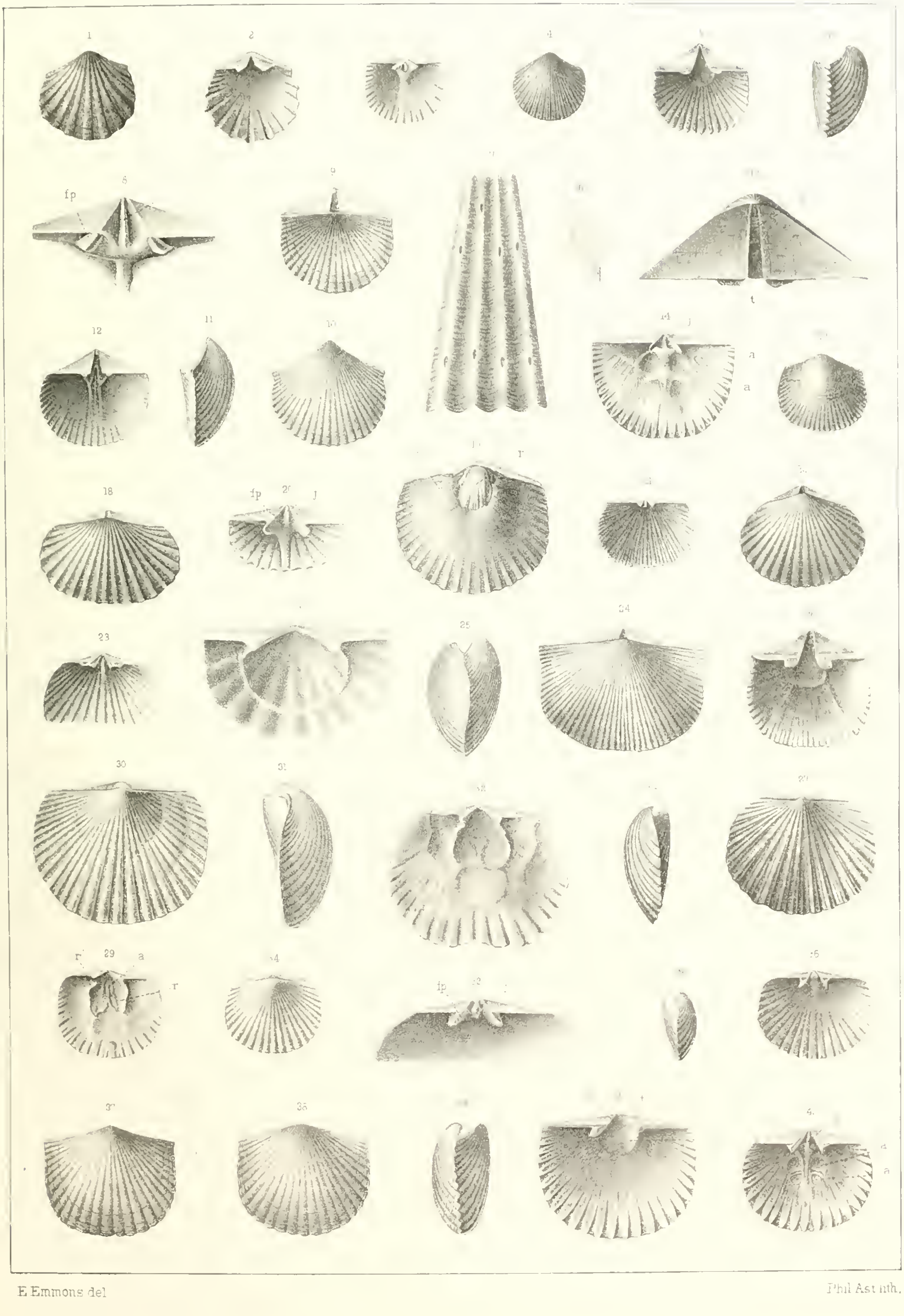
Niagara group. *Lockport, N. Y.*

For further illustration see Palæontology of New York, Volume II, plate lii, figs. 6, 7.

BRACHIOPODA.

Orthidæ

Generic Illustrations



E Emmons del

Phil Ast lith.

PLATE V A

(Figures 2, 4, 16–21, 24–40 by E. EMMONS; 1, 3, 5–14 by R. P. WHITFIELD; 15 by F. B. MEEK; 22 by PHILIP AST; 23 by J. C. McCONNELL.)

Legend. Δ. Deltidium.
j. Cardinal process.
fp. Crural plate.
t. Teeth.
b. Sockets.
a. Anterior adductor impressions.
a′. Posterior adductor impressions.
r. Diductor muscular impressions.
p. Pedicle-muscular impression.
o. Ovarian impressions.
v. Vascular markings.

HEBERTELLA, NOM. NOV.

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ORTHIS SINUATA, Hall.

Fig. 1. The interior of a pedicle-valve; giving the character of the muscular area, ovarian and vascular markings.
Fig. 2. An enlargement of the muscular area of the pedicle-valve; showing the large diductor (*r*), lineal central adductor (*a*) and the pedicle-scar (*p*). × 2.
Fig. 3. The interior of a brachial valve.
Fig. 4. The muscular and deltidial area of the brachial valve; showing the narrow, slightly thickened cardinal process (*j*), the large crural plates and the quadripartite impression of the adductor muscles. × 2.
Fig. 5. The exterior of a brachial valve.
Figs. 6, 7. Cardinal and profile views of the same specimen.
Fig. 8. Exterior of the pedicle-valve; the area and delthyrium of the opposite valve showing.
Hudson River group. *Cincinnati, Ohio.*

For further illustration see Palæontology of Ohio, Volume I, plate ix, fig. 4.

ORTHIS SINUATA, Hall. (?) (Compare *O. Maria*, Billings.)

Fig. 9. A view of the brachial valve and profile of a specimen doubtfully referred to this species.
Hudson River group. ————, *Ohio.*
Fig. 10 = 19, by error.

ORTHIS OCCIDENTALIS, Hall. (?)

Figs. 11, 12. Views of a small specimen with coarse, simple plications, and the median sinus incipiently developed; probably the young of this species.
Hudson River group. *Savannah, Illinois.*

ORTHIS INSCULPTA, Hall.

Fig. 13. The interior of a pedicle-valve; showing the muscular, vascular and ovarian markings. × 2.
Hudson River group. *Oxford, Ohio.*

For further illustration see Palæontology of Ohio, Volume I, plate ix, fig. 1.

PLÆSIOMYS, NOM. NOV.

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ORTHIS RETRORSA, Salter (= *O. Carleyi*, Hall).

Fig. 14. The interior of a pecicle-valve; showing the short dental lamellæ, subquadrate muscular area, the vascular and ovarian makings.
Fig. 15. A view of the pedicle-valve of the orignal specimen; showing the high area and retrorse beak of this valve.
Fig. 16. Profile of a large individual; showing the great convexity of the brachial valve and the degree of resupination of the beak of the pedicle-valve.
Hudson River group. *Oxford, Ohio.*

For further illustration, see Palæontology of Ohio, Volume I, plate xi, fig. 7.

ORTHIS SUBQUADRATA, Hall.

Fig. 17. The interior of the pedicle-valve; showing the component scars of the subquadrate muscular area, the lateral ovarian areas and the vascular impressions over the pallial region.
Figs. 18, 19. Brachial and cardinal views of a normal individual.
Hudson River group. *Oxford, Ohio.*

For further illustration, see Palæontology of Ohio, Volume I, plate ix, fig. 2.

PLATE V A—Continued.

ORTHIS PORCATA, McCoy.

Figs. 20, 21. Brachial and profile views of an average example; showing the rotundity of the brachial valve and the resupination of the opposite beak.

Middle Silurian. *Junction Cliff, Anticosti.*

For further illustration, see DAVIDSON, Silurian Brachiopoda, plate xxxii, figs. 12–20.

ORTHOSTROPHIA, HALL.

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ORTHIS HALLI. Safford (? = *O. strophomenoides*, Hall).

Fig. 22. A view of the pedicle-valve.

Fig. 23. A cardinal view of the conjoined valves of the same specimen.

Lower Helderberg group. *Perry county, Tennessee.*

ORTHIS STROPHOMENOIDES, Hall.

See Plate VI, figs. 32–34.

Fig. 24. The exterior of a brachial valve.

Fig. 25. A cardinal view of the same specimen; showing greater convexity than the preceeding species. (The relative position of the valves as represented in the figures 23 and 25 is reversed.)

Fig. 26. The interior of a brachial valve; showing the character of the cardinal process, muscular area, ovarian and vascular markings.

Fig. 27. The interior of the opposite valve. The muscular area is greatly thickened and is divisible into the adductor and diductor elements: the vascular sinuses are also very distinct.

Lower Helderberg group *Near Clarksville, N. Y.*

For further illustration, see Palæontology of New York, Volume III, plate xxiii, fig. 7.

PLÆSIOMYS, NOM. NOV.

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ORTHIS DEFLECTA, Conrad.

Figs. 28, 29. The exterior of the brachial and pedicle-valves.

Fig. 30. A cardinal view of the same specimen; showing the elevation of the area, the convex deltidium, and the convexity of the brachial valve.

Trenton horizon. *Dixon, Illinois.*

For further illustration, see Palæontology of New York, Volume I, plate xxxiB, fig. 5.

ORTHIS LORICULA, sp. nov.

Fig. 31. The cardinal area of the pedicle-valve; showing the deltidium.

Fig. 32. The exterior of the pedicle-valve.

Fig. 33. The interior of the brachial valve. The delthyrium is filled by a callosity which also supports the crural plates and the linear cardinal process; the deltidium is also present in an incipient condition.

Fig. 34. The interior of the pedicle-valve; showing the character of the muscular area, ovarian markings, etc.

Galena limestone. *Fountain, Minnesota.*

ORTHIS HOLSTONI, Safford.

Fig. 35. Profile of the type specimen.

Fig. 36. Cardinal view of the same; showing the wide delthyrium and elevated area of the pedicle-valve.

Fig. 37. A view of the brachial valve of the same specimen.

Trenton horizon. *Near Knoxville, Tennesee.*

ORTHIS SAFFORDI, sp. nov.

Figs. 38, 39, 40. Three views of the exterior of a specimen; showing its general form and the character of its surface markings.

Trenton horizon. *Near Knoxville, Tennessee.*

BRACHIOPODA.

Orthidæ

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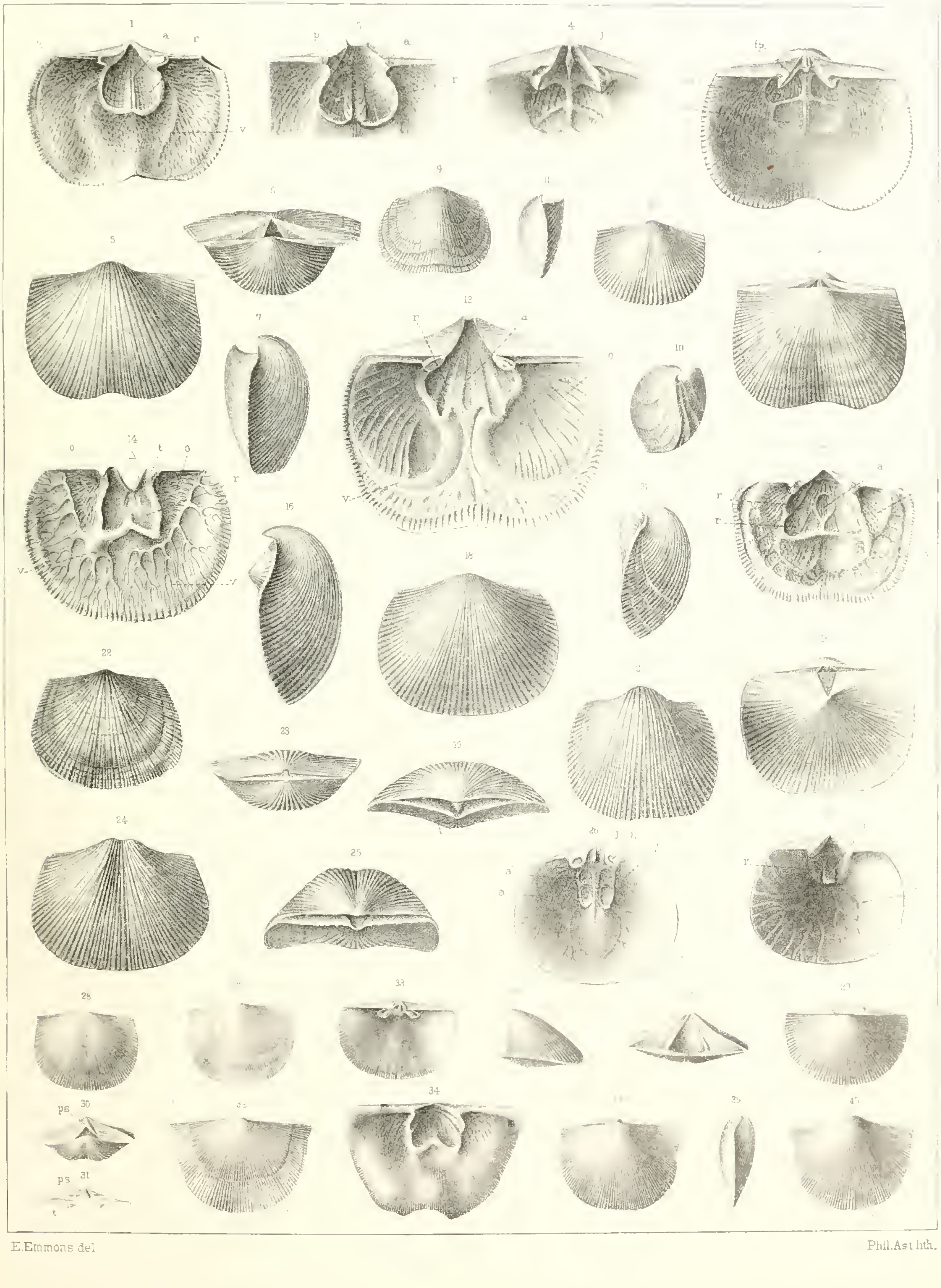

E. Emmons del | Phil. Ast lith.

PLATE V B.

(Figures 3, 4, 8, 15-21, 27-39, by R. P. WHITFIELD; 9, 22-26, by E. EMMONS, 10-11, by J. C. MCCONNELL.)

Legend. Δ. Deltidium.
j. Cardinal process.
t. Teeth.
b. Sockets.
c. Crura.
s. Septum.
p. Pedicle muscle.
a. Anterior adductor impressions.
a′. Posterior adductor impressions.
r. Anterior diductor impressions.
r′. Posterior diductor impressions.
o. Ovarian markings.
v. Vascular markings.

PLATYSTROPHIA, KING.

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ORTHIS BIFORATA, Schlotheim, var. LYNX, von Eichwald.

Fig. 1. A cardinal view of an average individual; showing the area and delthyrium of each valve. (The lines limiting the delthyrium are too strongly defined.)

Fig. 2. An exterior of the brachial valve of a smaller specimen.

Fig. 3. The interior of a brachial valve; showing the narrow, linear cardinal process, large crural plates and the quadripartite impression af the adductor muscles.

Fig. 4. The interior of a large pedicle-valve. The apical portion of the shell has been absorbed, being the usual condition in old shells of this form, thus exposing the impression of the pedicle-muscle. The specimen also shows the compact form of the muscular scars, the vascular trunks and ovarian markings.

Hudson River group. *Cincinnati, Ohio.*

ORTHIS BIFORATA, Schlotheim, var. LATICOSTA, Meek.

Figs. 5, 6, 7. Profile, brachial and front views; showing the high median fold characterizing this form.

Fig. 8. The interior of a brachial valve.

Fig. 9. An enlargement of the delthyrial portion of the brachial valve. The obsolescent character of the cardinal process is probably due, iu part, to reabsorption.

Hudson River group. *Cincinnati, Ohio.*

ORTHIS BIFORATA, Schlotheim.

Fig. 10. The exterior of the pedicle-valve. The surface is covered with fine granules which, however, are very rarely retained (and almost never visible in ordinary specimens). × 3.

Trenton limestone. *Trenton Falls, N. Y.*

For further illustration of PLATYSTROPHIA, see DAVIDSON, Silurian Brachiopoda, pl. xxxviii, figs. 11–25; Palæontology of Ohio, Volume I. plate x.

BILOBITES, LINNÉ.

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ORTHIS BILOBA, Linné.

Figs. 11, 12, 13, 14. Views; showing the variation in form in this species. Fig. 14 is of the type described by RINGUEBERG as *O. acutiloba.* × 3.

Niagara group. *Lockport, N. Y.*

ORTHIS VARICA, Conrad.

Figs. 15, 16, 17. Three views of the same specimen. × 2.

Fig. 18. The interior of the pedicle-valve; showing the area, delthyrium, teeth and outline of the muscular area. × 4.

Fig. 19. The interior of the brachial valve; showing the cardinal process, the great crura, large muscular area, and the pectinated surfaces of marginal contact. × 5.

Lower Helderberg group. *Near Clarksville, N. Y.*

HETERORTHIS, NOM. NOV.

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ORTHIS CLYTIE, Hall.

Fig. 20. A view of the brachial valve of the type-specimen; showing the area and foramen of the pedicle-valve.

Fig. 21. The interior of a pedicle-valve; showing the elongate scars of the cardinal muscles and the small adductor impressions.

Fig. 22. The interior of the brachial valve. The cardinal process is simple, but very high, and the crural plates are much elevated, terminating abruptly. Muscular area small and obscurely quadripartite.

Fig. 23. The articular area of the same valve; showing the divisions of the muscular area. × 2.

Fig. 24. The surface ornamentation, consisting of a fasciculate grouping of the radiating striæ, crossed by minute concentric lines. × 4.

Trenton horizon. *Near Frankfort, Ky.*

DALMANELLA, NOM. NOV.

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ORTHIS EVADNE, Billings.

Fig. 25. A view of the brachial valve of the type-specimen; showing area and foramen of opposite valve.

Fig. 26. The opposite side of the same specimen.

"*Point Lévis: in the upper part of Limestone No. 2, Quebec group.*"

ORTHIS TESTUDINARIA, Dalman.

Figs. 27, 28, 29. Three views of a small form which may prove to be a permanent variety of the species.

Fig. 30. The interior of the pedicle-valve of the same form.

Fig. 31. The interior of the brachial valve. × 2.

Trenton horizon. *Mineral Point, Wisconsin.*

Fig. 32. The exterior of the pedicle-valve of a normal individual.

Fig. 33. The exterior of the brachial valve of a somewhat larger specimen.

Fig. 34. A profile of the same.

Fig. 35. The interior of a pedicle-valve; showing the character of the muscular area.

Fig. 36. The interior of a brachial valve, retaining the articulating apophyses and the subdivision of the muscular area.

Fig. 37. The central cardinal portion of a similar valve, enlarged to show with greater distinctness the structure of the articulating apparatus.

Hudson River group. *Cincinnati, Ohio.*

Fig. 38. The interior of a large pedicle-valve.

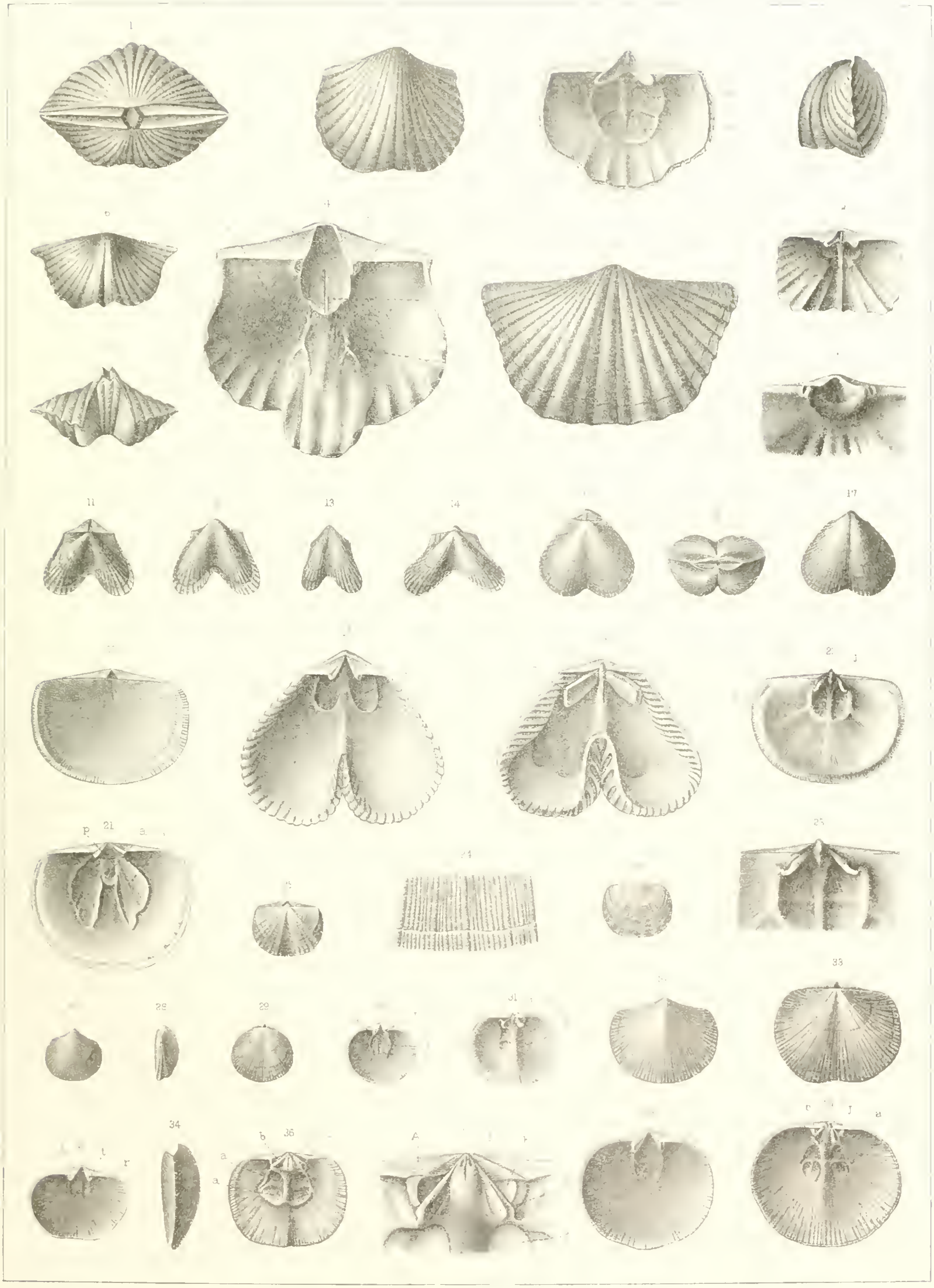
Trenton limestone. *Middleville, N. Y.*

Fig. 39. The interior of a brachial valve. × 2.

Trenton limestone. *Lowville, N. Y.*

BRACHIOPODA.

Orthidæ



E. E. Whitfield del. Phil Ast lith.

PLATE Vc.

(Figures 1, 2, 6-18, 25-41, by R. P. Whitfield. 4, 5, 19, 42-47, by E. Emmons. 3, 20-24, by J. C. McConnell.)

Legend. Δ. Deltidium.
t. Teeth.
b. Sockets.
fp. Crural plates.
j. Cardinal process.
c. Crura.
a. Anterior adductor scars.
a′. Posterior adductor scars.
r. Diductor scars.
o. Ovarian markings.
v. Vascular markings.

DALMANELLA, NOM. NOV.

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Orthis emacerata, Hall.

Fig. 1. The central cardinal portion of the interior of a brachial valve; showing the processes and muscular imprints. × 3.

Fig. 2. The exterior of a brachial valve.

Hudson River group. *Cincinnati, Ohio.*

For further illustration, see Palæontology of Ohio, Volume 1, plate viii, figs. 1, 2.

Orthis Meeki, Miller.

Fig. 3. The interior of a brachial valve; showing the cardinal process, crura and muscular scars. The apparent impressions in the umbo-lateral regions are due to abnormal thickening of the test. × 2.

Hudson River group. *Spring Valley, Minnesota.*

Orthis Stonensis, Safford.

Fig. 4. Profile of a specimen with valves conjoined. × 2.

Fig. 5. A view of the pedicle-valve of the same specimen; showing the alternating, fasciculate character of the radiating striæ. × 2.

Orthis subæquata, Conrad.

Fig. 6. A view of the brachial valve of the original specimen; showing the area and foramen of the opposite valve.

Figs. 7, 8. Profile and cardinal views of the same.

Fig. 9. The articular and muscular area of the brachial valve. × 3.

Figs. 10, 11. Interiors of the pedicle and brachial valves.

Trenton horizon. *Mineral Point, Wisconsin.*

For further illustration, see Palæontology of New York, Volume I, plate xxxii, fig. 2.

Orthis perveta, Conrad.

Fig. 12. View from the brachial valve of the original specimen.

Figs. 13, 14. Brachial and profile views of a larger individual.

Trenton horizon. *Mineral Point, Wisconsin.*

For further illustration, see Palæontology of New York, Volume 1, plate xxxii, fig. 5.

Orthis elegantula, Dalman.

Figs. 15, 16. Opposite sides of the same individual; showing the form of the species as occurring at this locality.

Fig. 17. The interior of a pedicle-valve, somewhat enlarged.

Fig. 18. The interior of a brachial valve; showing the muscular impressions and articular processes. × 2.

Niagara group. *Waldron, Indiana.*

Fig. 19. Cardinal view of the central portion of the brachial valve; showing the composition of the cardinal process, the great elevation of the crural plates and crura, and their furrowed or crenulated outer walls. × 3.

Upper Silurian limestone. *Island of Gotland.*

For further illustration, see Davidson, Silurian Brachiopoda, pl. xxvii, figs. 1–9; Hall, Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., pl. xxi, figs. 11–17.

ORTHIS ARCUARIA, sp. nov.

(See Supplement for description.)

Figs. 20, 21. Two views of a silicified, partially exfoliated shell; showing somewhat the contour of *O. elegantula*, but having a more strongly biconvex form.

Niagara group. *Perry county, Tennessee.*

ORTHIS WISBYENSIS, Lindström.

Fig. 22. Profile of the pedicle-valve.

Fig. 23. The interior of the same valve.

Fig. 24. The interior of the brachial valve; showing the cardinal process, crural plates and muscular scars. × 2.

Upper Silurian limestone. *Island of Gotland.*

ORTHIS SUBCARINATA, Hall.

Figs. 25, 26, 27, 28. Views of the exterior of a normal individual; showing its form and contour.

Fig. 29. The interior of a brachial valve.

Fig. 30. The interior of a pedicle-valve.

Fig. 31. A natural cast of the interior of the brachial valve; showing the limits of the muscular area, the ovarian spaces and the main vascular trunks.

Fig. 32. A similar internal cast of the opposite valve, preserving the ramifications of the vascular sinuses, and showing also the ovarian spaces and muscular scars.

Fig. 33. Posterior view of the cardinal area of the brachial valve; showing the subdivision of the cardinal process and the elevation of the crural plates.

Lower Helderberg group. *Near Clarksville, N. Y.*

For further illustration, see Palæontology of New York, Volume III, plate xii, figs. 7–21.

ORTHIS PERELEGANS, Hall.

Fig. 34. The interior of a brachial valve; showing the divergent ridges extending from the line of separation between the anterior and posterior elements of the adductor muscle.

Fig. 35. Posterior view of the cardinal area of a brachial valve.

Lower Helderberg group. *Near Clarksville, N. Y.*

For further illustration, see Palæontology of New York, Volume III, plate xiii, figs. 4–12.

ORTHIS LENTICULARIS, Vanuxem (= *O. lentiformis*, Hall).

(See note on page 224.)

Figs. 36, 37. Two views of a small individual.

Corniferous limestone. *LeRoy, N. Y.*

Figs. 38, 39, 40. Views of a larger, more biconvex specimen.

Fig. 41. The interior of a pedicle-valve; showing the character of the muscular area.

Corniferous limestone. *Caledonia, N. Y.*

ORTHIS LEONENSIS, Hall.

Figs. 42, 43. Interiors of the brachial and pedicle-valves taken from impressions of natural moulds.

Chemung group. *Cattaraugus county, N. Y.*

For further illustration, see Palæontology of New York, Volume IV, plate viii, figs. 3–8.

ORTHIS SUPERSTES, sp. nov.

(See Supplement for description.)

Fig. 44. Profile; showing the convexity of the shell.

Fig. 45. A view of the same specimen from the brachial valve.

Fig. 46. An internal cast of the pedicle-valve; showing traces of the vascular sinuses.

Fig. 47. The interior of the opposite valve; retaining similar radiating furrows about the muscular area.

Chemung group. *Howard, N. Y.*

BRACHIOPODA.

Orthidæ

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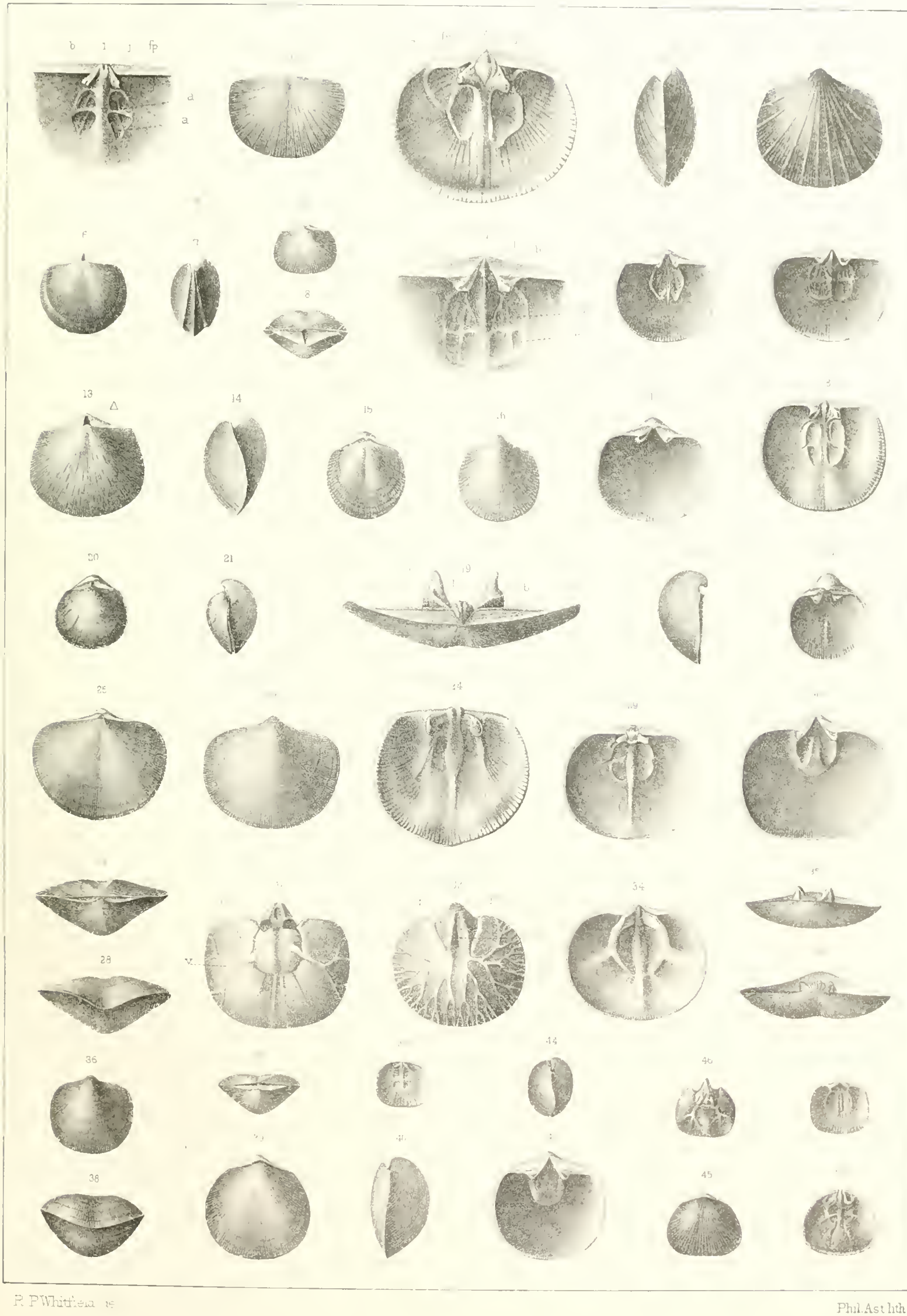

R. P. Whitfield, del. — Phil. Ast. lith.

PLATE VI.

(Figures 1-34, by R. P. WHITFIELD.)

Legend. A. Cardinal area.
t. Teeth.
b'. Sockets.
d. Dental lamellæ.
c. Crura.
s. Median septum.
j. Cardinal process.
p. Pedicle-area.
a. Anterior adductor scars.
a'. Posterior adductor scars.
r. Anterior diductor scars.
r'. Posterior diductor scars.
v. Vascular markings.
o. Ovarian markings.

RHIPIDOMELLA, ŒHLERT.

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ORTHIS HYBRIDA, Sowerby.

Figs. 1, 2, 3. Three views of an average individual of the American form referred to this species.

Fig. 4. The interior of the brachial valve. The character of the diductor muscular scars is here incorrectly represented, the impression being quadripartite and not flabellate.

Fig. 5. The interior of the pedicle-valve; showing the expanded muscular scars.

Niagara group. *Lockport, N. Y.*

For further illustration, see DAVIDSON, Silurian Brachiopoda, plate xxvii, figs. 1-9; HALL, Palæontology of New York, Volume II, plate lii, fig. 3; Twenty-eighth Rept. N. Y. State Mus. Nat. Hist., pl. xxi, figs. 18-25.

ORTHIS PENELOPE, Hall.

(See Plate VI A. fig. 10.)

Figs. 6, 7, 8. Three views, giving the external characters of a normal mature individual.

Fig. 9. The interior of a brachial valve; showing the articulating apparatus. The muscular area is quadripartite rather than flabellate.

Fig. 10. The interior of a small pedicle-valve.

Fig. 11. Similar view of an older shell.

Fig. 12. The interior of a pedicle-valve, which shows the thickening about the muscular impressions, accompanying senility.

Fig. 13. An enlargement of the surface striæ; showing the openings of the oblique tubules upon the striæ and the scattered punctæ.

Hamilton group. *Western New York.*

For further illustration, see Palæontology of New York, Volume IV, plate vi, fig. 2.

ORTHIS VANUXEMI, Hall.

(See Plate VI A, figs. 7, 8.)

Fig. 14. An enlargement of the surface striæ.

Fig. 15. An internal cast of the pedicle-valve; showing the pedicle-scar and other muscular impressions.

Hamilton group. *Cumberland, Maryland.*

For further illustration, see Palæontology of New York, Volume IV, plate vi, fig. 3.

ORTHIS LEUCOSIA, Hall.

(See Plate VI A, fig. 9.)

Fig. 16. The interior of the pedicle-valve.

Hamilton group. *Western New York.*

For further illustration, see Palæontology of New York, Volume IV, plate vii, fig. 4.

SCHIZOPHORIA, KING.

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ORTHIS TIOGA, Hall.

Fig. 17. The exterior of a brachial valve.

Fig. 18. An internal cast of a pedicle-valve.

Chemung group. *Near Elmira, N. Y.*

For further illustration, see Palæontology of New York, Volume IV, plate viii, figs. 20-29.

PLATE VI—Continued.

RHIPIDOMELLA, Œhlert.

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Orthis Oweni, sp. nov.

(See Supplement for description.)

Fig. 19. The exterior of a brachial valve.

Figs. 20, 21. Interiors of pedicle and brachial valves, respectively.

"Knobstone group" of Owen, = age of the Waverly. *Button-mould Knobs, Kentucky.*

SCHIZOPHORIA, King.

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Orthis carinata, Hall.

Fig. 22. An internal cast of a pedicle-valve; showing the character of the muscular area, at the anterior margin of which are seen traces of the vascular sinuses.

Chemung group. *Near Painted Post, N. Y.*

For further illustration, see Palæontology of New York, Volume IV, plate viii, figs. 30–32.

Orthis Swallovi, Hall.

Figs. 23, 24. The exterior and interior of the pedicle-valve.

Burlington limestone. *Burlington, Iowa.*

Orthis Tulliensis, Hall.

Figs. 25, 26, 27. Three views of a normal individual; showing the great convexity of the brachial valve and the shallow pedicle-valve.

Fig. 28. An internal cast of the brachial valve; showing the quadruple muscular impression and the principal vascular trunks. At *y* is the filling of the rostral cavity of the opposite valve.

Fig. 29. An internal cast of the pedicle-valve.

Tully limestone. *Keuka Lake, N. Y.*

For further illustration, see Palæontology of New York, Volume IV, plate vii, fig. 5.

Orthis propinqua, Hall.

Fig. 30. An internal cast of the brachial valve. The subdivision and the course of the vascular sinuses are very sharply retained.

Corniferous limestone. *Avon, N. Y.*

For further illustration, see Palæontology of New York, Volume IV, plate v, fig. 3.

Orthis impressa, Hall.

(See Plate VI A, figs. 26, 27.)

Fig. 31. An internal cast of the pedicle-valve; showing the subdivisions of the muscular area, and the unusual arrangement of the vascular sinuses.

Chemung group.

For further illustration of this species, see Palæontology of N.Y., Volume IV, pl. viii, figs. 11–19.

ORTHOSTROPHIA, Hall.

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Orthis strophomenoides, Hall.

(See Plate V A, figs. 24–27.)

Fig. 32. The exterior of an imperfect brachial valve.

Fig. 33. An internal cast of the pedicle-valve; showing the very small muscular area, the ovarian markings in the umbo-lateral regions, and the vascular sinuses over the pallial region.

Fig. 34. An internal cast of the brachial valve, retaining the impression of the simple cardinal process, and showing the four sharply defined adductor scars, the ovarian markings and the ramified vascular sinuses.

Lower Helderberg group. *Near Clarksville, N. Y.*

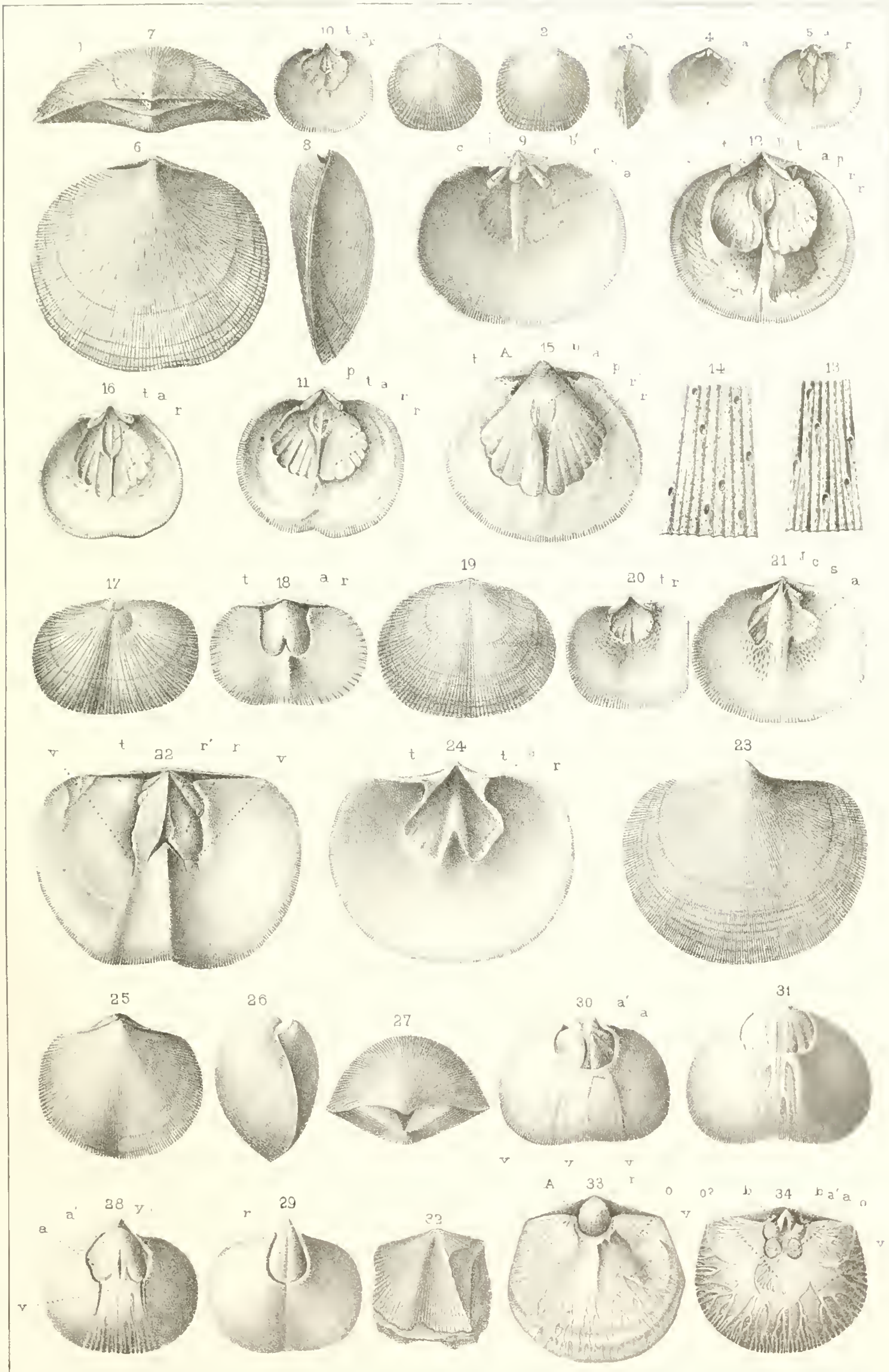

PLATE VI A.

(Figures 7-9, 11, 18-25, 29, 32, by E. EMMONS; 1, 2, 13-17, 26, 27, by G. B. SIMPSON, 3, 4, 6, by R. P. WHITFIELD, 10, 30, 31, by J. C. MCCONNELL; 5, 28, by J. M. CLARKE; 12, copy.)

Legend. t. Teeth.
j. Cardinal process.
b. Sockets.
fp. Crural plates.
c. Crura.
dc. Deltidial covering (brachial valve).
p. Pedicle-muscle.
a. Anterior adductor scars.
a′. Posterior adductor scars.
x. Accessory adductor (brachial valve)
r. Diductor scar.
o. Ovarian markings.
v. Vascular markings.

RHIPIDOMELLA, ŒHLERT.

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ORTHIS CIRCULUS, Hall.

Figs. 1, 2. Opposite sides of the original specimen of this species.
Clinton group. *Reynale's Basin, N. Y.*

ORTHIS OBLATA, Hall.

Fig. 3. The interior of a small brachial valve.
Fig. 4. The interior of a pedicle-valve of the usual dimensions; showing the muscular area.
Lower Helderberg group. *Near Clarksville, N. Y.*
For further illustration of this species, see Palæontology of New York, Volume III, plate 10.

ORTHIS MUSCULOSA, Hall.

Fig. 5. The interior of a pedicle-valve; showing the extravagant development of the diductor scars, the narrow adductors and the large impression of the pedicle muscle.
Oriskany sandstone. *Cumberland, Maryland.*
For further illustration, see Palæontology of New York, Volume III, plate xci, figs. 1–3.

ORTHIS PELORIS, Hall.

Fig. 6. An internal cast of the pedicle-valve. The area covered by the muscular impressions is unusually restricted though normal for the species.
Schoharie grit. *Near Clarksville, N. Y.*
For further illustration, see Palæontology of New York, Volume IV, plate iv, figs. 1, 8–10.

ORTHIS VANUXEMI, Hall.

(See Plate VI, figs. 14, 15.)

Fig. 7. The interior of a brachial valve, retaining with unusual distinctness the four scars of the adductor muscles. The ridges radiating from the anterior margin of the muscular area, are probably of vascular origin.
Hamilton group. *Canandaigua Lake, N. Y.*
Fig. 8. An internal cast of the pedicle-valve.
From Drift of the Hamilton group. *Near Elmira, N. Y.*
For further illustration, see Palæontology of New York, Volume IV, plate vi, fig. 3.

ORTHIS LEUCOSIA, Hall.

(See Plate VI, fig. 16.)

Fig. 9. An internal cast of the pedicle-valve, with strong muscular scars, and showing the pitting of the ovarian spaces (indicating a premature senile condition ?).
From Drift of the Hamilton group. *Near Elmira, N. Y.*

ORTHIS PENELOPE, Hall.

(See Plate VI, figs. 6–13.)

Fig. 10. An enlargement of the cardinal area of the brachial valve, giving the structure in detail. × 3.
Hamilton group. *Canandaigua Lake, N. Y.*

ORTHIS, sp. ? (compare *O. Penelope*).

Fig. 11. A pedicle-valve, from which the shell has partially exfoliated; showing the muscular impressions on the matrix.
Waverly group. *Granville, Ohio.*

ORTHIS MICHELINI, L'Eveillé.

Fig. 12. View of the brachial valve of a specimen retaining the spines on a portion of its surface. Copied from DAVIDSON's Monograph of the Carboniferous Brachiopoda, pl. xxx, fig. 7.
Carboniferous shales. *Gateside, Ayrshire, Scotland.*
For further illustration, see DAVIDSON, Carboniferous Brachiopoda, plate xxx, figs. 6–12.

ORTHIS BURLINGTONENSIS, Hall.

Fig. 13. The exterior of a pedicle-valve.
This species has been regarded by DAVIDSON, MEEK and some other authors as identical with *O. Michelini*, L'Eveillé. A comparison of the American form with authentic figures of the European species, shows a degree of difference inconsistent with the identity claimed.
Burlington limestone *Sageville, Illinois.*
For further illustration, see Geol. of Iowa, Vol. I, part ii, pl. xii, fig. 4; and pl. xx of this volume.

Orthis Thiemii, White.

Fig. 14. The interior of the pedicle-valve. × 3.

Fig. 15. The interior of a brachial valve which retains the bases of the crura at the extremities of the crural plates. × 3.

Burlington limestone (arenaceous beds). *Burlington, Iowa.*

The specimen referred to this species, with doubt, in Palæontology of New York, Volume IV, p. 63, plate viii, fig. 2, is not *O. Thiemii*, and will require a different reference.

Orthis Missouriensis,* Swallow.

Figs. 16, 17. Interiors of the brachial and pedicle-valves. The asymmetry of the muscular area is an accidental misrepresentation.

Choteau limestone. *Pike county, Missouri.*

Orthis dubia, Hall.

Figs. 18, 22. Views of opposite sides of the same specimen; showing the peculiar form of the shell. × 2.

St. Louis group. *Lebanon, Kentucky.*

Fig. 19. The interior of a pedicle-valve; showing the large delthyrium and strong teeth with the absence of a cardinal area. × 2.

The limitations of the muscular area are shown, but its subdivisions are not preserved.

St. Louis group. *Lanesville, Indiana.*

Fig. 20. Interior of the pedicle-valve, retaining more distinctly the subdivisions of the muscular area. × 2.

Chester limestone. *Litchfield, Kentucky.*

Fig. 21. The interior of a brachial valve; showing the greatly thickened and elevated hinge-plate bearing the cardinal process and crural plates. × 2.

St. Louis group. *Lanesville, Indiana.*

SCHIZOPHORIA, King.

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Orthis senectus, sp. nov.

Fig. 23. The exterior of a pedicle-valve; showing its depression over the pallial region.

Fig. 24. An internal cast of the pedicle-valve; showing the diductor and adductor scars.

Clinton group. *Reynale's Basin, N. Y.*

Orthis multistriata, Hall.

Fig. 25. An internal cast of the brachial valve of one of the original specimens; showing the subdivision of the muscular area and the diverging vascular sinuses.

Lower Helderberg group. *Near Clarksville, N. Y.*

For further illustration, see Palæontology of New York, Volume III, plate xv, fig. 2.

Orthis impressa, Hall.

(See Plate VI, fig. 31.)

Figs. 26, 27. Two internal casts of the brachial valve, which retain with unusual distinctness the muscular, vascular and ovarian markings, and also the impression of the multipartite cardinal process.

Chemung group. *Lawrenceville, Pennsylvania.*

For further illustration, see Palæontology of New York, Volume IV, plate viii, figs. 11–19.

Orthis Iowensis, Hall.

Fig. 29. The interior of a pedicle-valve; showing the muscular area with a strongly thickened and elevated central adductor impression.

Chemung group. *Lime Creek, Iowa.*

See Geology of Iowa, Volume I, part ii, plate ii, figs. 4 a–i. 1858.

Orthis Macfarlanii, Meek.†

Fig. 28. The interior of a portion of the brachial valve, retaining at (*x*) the accessory adductor impressions.

Chemung group. *High Point, N. Y.*

Fig. 30. Posterior view of a specimen; showing the great disparity in the convexity of the two valves, the lower being the brachial valve.

Fig. 31. Profile of another individual; showing the gibbosity of the brachial valve.

Chemung group. *Howard, N. Y.*

Fig. 32. An internal cast of a large brachial valve in which the muscular impressions are unsymmetrically developed. The cast of the cardinal process shows its subdivision on the posterior face.

Chemung group. *High Point, N. Y.*

Compare figures 5 *a–k*, *Orthis Tulliensis*, Palæontology of New York, Volume IV, plate 7.

* This name was preoccupied by *Orthis Missouriensis*, Shumard; Reports I and II of the Geological Survey of Missouri, 1855, part ii, page 205, plate C, figs. 9 a, b. That species, if belonging to the *Orthidæ*, should be placed under Orthis as restricted, or under Dinorthis, thus leaving *Orthis Missouriensis* of Swallow under the genus Rhipidomella.

† The species of Orthis — Schizophoria, described as *O. propinqua*, *O. Tulliensis*, *O. impressa*, *O. Iowensis* and *O. Macfarlanii*, present so many features in common that farther study and comparison should be given them to determine the actual value of the characters on which the specific distinction has been based, and whether these differences coincide with their geological relations.

BRACHIOPODA.

Orthidæ

Generic Illustrations

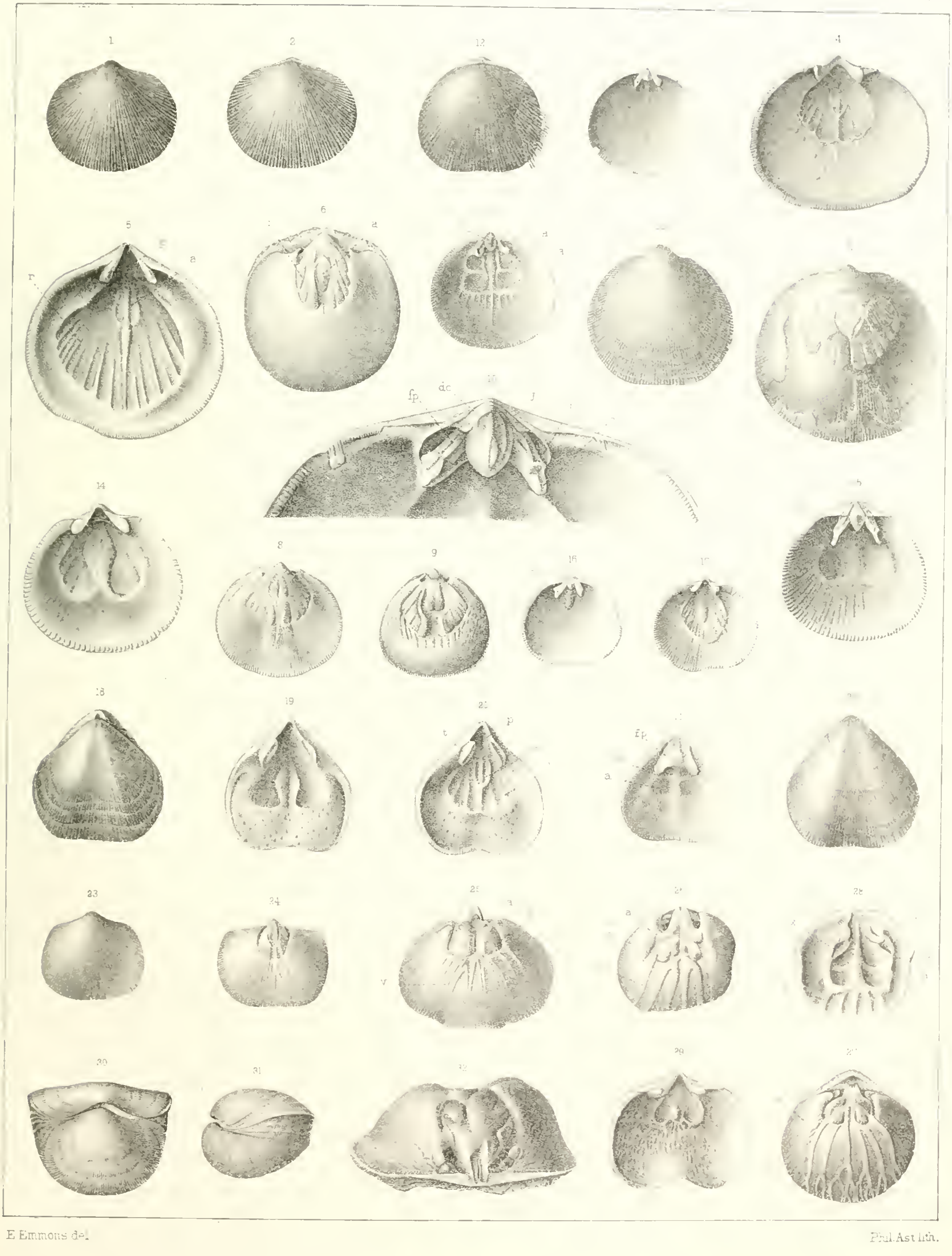

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PLATE VII.

(Figures 1-24, 29-32 by R. P. Whitfield; 33-35 by F. B. Meek; 25-28 copies.)

Legend. A. Cardinal area.
DA. Cardinal area, brachial valve.
VA. Cardinal area, pedicle-valve.
F. Foramen.
D. Deltidium, pedicle-valve.
Δ. Delthyrium, pedicle-valve.
C. Deltidium, brachial valve.
t. Teeth.
d. Dental lamellæ.
b. Dental sockets.
j. Cardinal process.
c. Crura.
s. Septum.
x. Umbonal vault.
y. Cast of umbonal vault.
p. Pedicle muscular scar.
a. Anterior adductors.
a′. Posterior adductors.
r. Diductors.

RHIPIDOMELLA, Œhlert.

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(See Plates VI, VIa.)

Orthis Pecosi, Marcou.

Fig. 1. An entire specimen viewed from the brachial valve. × 2.

Fig. 2. Profile of the same. × 2.

Fig. 3. The interior of the pedicle-valve; showing the narrow cardinal area and the characteristic muscular scars. × 2.

Fig. 4. An enlargement of the surface; showing the openings of the oblique tubules and minute punctæ.
Coal Measures. *Near Springfield, Illinois.*

Orthis Penniana, Derby.

Fig. 5. View from the pedicle-valve.

Fig. 6. Profile of the same specimen.

Fig. 7. The interior of the pedicle-valve; showing the nearly obsolete cardinal area and the strong muscular impressions, especially that of the pedicle-scar.

Fig. 8. The interior of an imperfect brachial valve; showing the cardinal process, crural bases and muscular impressions.

Fig. 9. The cardinal portion of the same specimen, enlarged to show the low, thick cardinal process, the very prominent crura and the quadripartite character of the adductor area. × 3.

Fig. 10. An enlargement of the external surface; showing strong punctation.
Coal Measures. *Itaituba, Brazil.*

ORTHOTICHIA, nom. propos.

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Orthis (?) Morganiana, Derby.

Figs. 11, 12. Interiors of imperfect brachial valves; showing the cardinal process, the greatly elevated and curved crura supported by septal plates which are produced about the sides of the muscular area. In fig. 12 are also seen the accessory adductor scars described by Dr. Derby.

Fig. 13. Section in profile of fig. 12; showing the extent of the crural plates and the elevation of the crura.

Fig. 14. The interior of a pedicle-valve, retaining the long dental lamellæ and the median septum.

Fig. 15. A slightly oblique view of another interior of this valve; showing more distinctly the elevation of the teeth and the outline of the muscular area.
Coal Measures. *Itaituba, Brazil.*

Genus BILLINGSELLA, gen. nov.

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(See Plate VIIa, figs. 7–9.)

Billingsella Pepina, Hall.

Fig. 16. The exterior of a brachial valve; drawn from a gutta-percha impression of a natural mould.

Fig. 17. A natural cast of the interior of the brachial valve.

Fig. 18. The exterior of the pedicle-valve.

Fig. 19. A natural cast of a pedicle-valve; showing the high cardinal area, the convex deltidium, the filling of the rostral cavity and the vascular sinuses in the pallial region.
Potsdam sandstone. *Lake Pepin, Wisconsin.*

PLATE VII—Continued.

Genus HEMIPRONITES, Pander.

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Hemipronites, sp. ?

Fig. 20. A view of the pedicle-valve, the cardinal area being in the plane of vision. The area of the opposite valve and the deltidia of both valves are shown. × 2.

Fig. 21. A cardinal view of the same specimen ; showing the characteristic contour upon which is based the separation of these forms from Clitambonites. × 2.

Fig. 22. A specimen cut horizontally across the umbonal region of the pedicle-valve ; showing the united dental lamellæ supported by a median septum. × 2.
Lower Silurian. *Russia.*

Genus CLITAMBONITES, Pander

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Clitambonites adscendens, Pander.

Fig. 23. A cardinal view, giving the subpyramidal contour characterizing this genus ; showing also the foramen in the deltidium. × 2.

Fig. 24. A pedicle-valve with the apex cut away; showing the peculiar internal structure of this valve. × 2.
Lower Silurian. *Russia.*

For further illustration, see Pander, Beiträge zur Geogn. russ. Reiches, plates xvii, xviii, and de Verneuil, Géologie de la Russie et des Mont. de l'Oural, plate xii, fig. 3.

Clitambonites (Orthisina) anomala, Schlotheim.

Fig. 25. A view of the pedicle-valve ; showing the great retrorsion of the apex, the high cardinal area of the pedicle-valve, and the perforated deltidium ; and also the area and deltidium of the opposite valve. (After de Verneuil, Géol. Russ. et des Mont. de l'Oural, plate xii, fig. 2*b*.)

Fig. 26. The interior of the brachial valve ; showing the extreme development of the cardinal area and deltidium, the latter entirely obscuring the cardinal process ; the character of the muscular and vascular scars is also distinctly seen. (After Davidson.)

Fig. 27. The interior of a pedicle-valve. (After Davidson.)
For further illustration, see de Verneuil, Géol. Russ. et des Mont. de l'Oural, plate xii, fig. 2.

Clitambonites plana, Pander.

Fig. 28. The interior of the pedicle-valve ; showing the radiating ridges beneath the spondylium. (After Davidson, Introd. Foss. Brach., plate viii, fig. 153.)

Genus SCENIDIUM, Hall.

(See Plate VIIa.)

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Scenidium pyramidale, Hall.

(See Plate VIIa, figs. 29, 30.)

Fig. 29. View of the type-specimen ; showing the open delthyrium in each valve. × 2.

Fig. 30. A cardinal view : showing the size of the areas of the two valves and character of the delthyrium. × 2.

Niagara group. *Lockport, N. Y.*

Scenidium insigne, Hall.

Fig. 31. A view of the brachial valve ; showing the concave plate (d) in the delthyrium of the pedicle-valve. × 8.

Fig. 32. The opposite side of the same specimen, pedicle-valve. × 8.

Fig. 33. A cardinal view of conjoined valves ; showing the concave plate in the delthyrium (d), the hinge-plate (a) and the median septum (s). × 8.

Fig. 34. The interior of the brachial valve ; showing the elevated hinge-plate and the prominent median septum. × 8.

Fig. 35. The interior of a pedicle-valve with an open delthyrium. × 8.
Lower Helderberg group. *Near Clarksville, N. Y.*

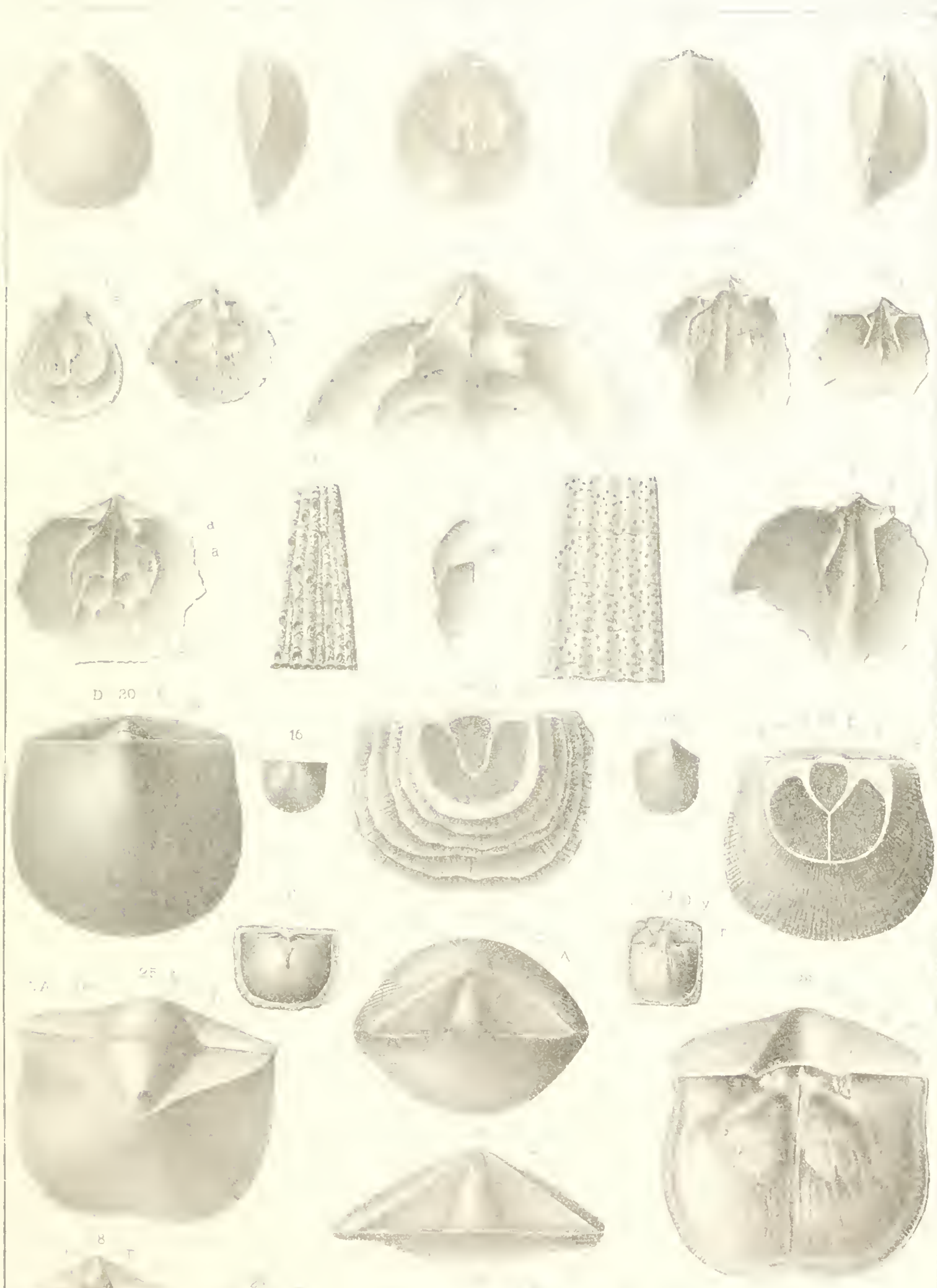

PLATE VII A.

(Figures 1-12, 14-21, 25, 28-31, 33-42, 44, 46, 48-53 by E. EMMONS; 26, 27, 32 by J. M. CLARKE, 45 by G. B. SIMPSON; 47 by R. P. WHITFIELD; 13, 22-24, 43 copies.)

Legend. D. Deltidium.
j. Cardinal process.
t. Teeth.
l. Spondylium.
fp. Crural plates.
c. Crura.
s. Median septum.
s′. Lateral septum.
s″. Accessory lateral septum.
a. Anterior adductor impressions.
a′. Posterior adductor impressions.

GENUS BILLINGSELLA, GEN. NOV.

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ORTHIS (BILLINGSELLA ??) LAURENTINA, Billings.

Fig. 1. View of the brachial valve; showing the simple plications, area and deltidium of the opposite valve.

Fig. 2. Profile of the same specimen.

Fig. 3. The interior of the pedicle-valve; showing the cardinal area, teeth and covered delthyrium; the outline of the muscular area and the median ridge.

Fig. 4. The interior of the brachial valve, retaining the simple cardinal process and the crural plates.

Fig. 5. The central cardinal portion of both valves, enlarged to show the character of the deltidia. On the brachial valve the deltidium is incomplete, the lateral portions not having united, and thus exposing the posterior edge of the cardinal process. × 3.

Fig. 6. The same parts in another specimen in which the deltidium of the brachial valve is nearly complete. × 3.

Anticosti group. *Anticosti.*

BILLINGSELLA PEPINA, Hall.

Fig. 7. An internal cast of the pedicle-valve. × 3.

Fig. 8. The interior of the same valve, from a gutta-percha impression of a natural mould; showing the broad cardinal area, the convex deltidium, teeth, outline of the muscular area and a single pair of vascular trunks. × 3.

Fig. 9. The interior of a brachial valve; showing the minute, linear cardinal process, and the small, slightly divergent crural plates. × 3.

Potsdam sandstone. *Lake Pepin, Wisconsin.*

For further illustration of the species, see Report of the Geological Survey of Wisconsin, Volume IV, plate i, figures 4, 5. For illustration of *Orthisina orientalis*, a congeneric form, see Bulletin Am. Mus. Nat. Hist., Volume 1, No. 5, p. 144, plate xiv, fig. 6.

ORTHIS (??) MYCALE, Billings.

Fig. 10. The exterior of a brachial valve, from the original specimen.

Fig. 11. The interior of the same specimen, enlarged; showing the quadripartite muscular imprint and the crural plates. There is no evidence of a cardinal process in the delthyrium. × 2.

"*Point Lévis: in the upper part of Limestone No. 2, Quebec group.*" (BILLINGS.)

ORTHIS (??) TRITONIA, Billings.

Fig. 12. The central portion of the interior of a brachial valve, enlarged. Here, as in the preceding species, there is no trace of a cardinal process, though the quadruple division of the muscular imprint indicates that this is the brachial and not the pedicle-valve. From one of the original specimens. × 3.

Fig. 13. The exterior of the brachial valve. (After BILLINGS.)

"*Point Lévis; in the upper part of Limestone No. 2, Quebec group.*" (BILLINGS.)

GENUS PROTORTHIS, GEN. NOV.

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PROTORTHIS BILLINGSI, Hartt.

Fig. 14. The exterior of a pedicle-valve. × 2.

Fig. 15. The interior of a brachial valve. × 2.

Fig. 16. The exterior of a small pedicle-valve; showing the concave plate or spondylium which closes the delthyrium below. × 3.

Fig. 17. A cardinal view of the same specimen. × 3.

Fig. 18. An enlargement of the surface of an internal cast. The granules may be casts of punctæ on the inner layer of the shell. × 6.

Fig. 19. An enlargement of the external surface of the shell; showing the sharp concentric striæ crossing the alternating plications. × 6.

Fig. 20. The central cardinal portion of the brachial valve; showing the broad, incurved delthyrium with a thickened area at its base, and the absence of a cardinal process. × 6.

St. John group. *St. John, N. B.*

Protorthis Quacoensis, Matthew.

Fig. 21. The interior of a pedicle-valve. × 2.

St. John group. *Portland, N. B.*

For other illustration, see Trans. Royal Society of Canada, Sec. IV, 1885, plate v, figs. 20 *a–c*.

Genus ORTHIDIUM, gen. nov.

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Orthidium gemmicula, Billings.

Figs. 22, 23, 24. Three views of this shell. (After Billings.)

Fig. 25. The interior of a brachial valve; showing the simple, erect cardinal process, coalesced with the crural plates. × 4.

"*Point Lévis: in the upper part of the Limestone No. 2, Quebec group.*" (Billings.)

Sub-genus POLYTŒCHIA, sub-gen. nov.

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Clitambonites (Polytœchia) apicalis, Whitfield.

Fig. 26. The cardinal portion of the pedicle-valve. The deltidium has been removed exposing the concave spondylium (l) supported by a median septum (s) and lateral septa (s'). The accessory lateral ridges (s'') are also seen. × 3.

Fig. 27. The cardinal portion of the brachial valve; showing in profile the lateral portions of the deltidium partially enclosing the simple cardinal process. The crural plates are very divergent and nearly parallel to the hinge-line. × 3.

Figs. 28, 29, 30. Three views of the original specimen of the species, the last showing the high cardinal area and convex deltidium. × 3.

Calciferous beds. *Fort Cassin, Vermont.*

For other illustration, see Bull. American Mus. Nat. Hist., Vol. I, plate xxiv, figs. 1–5.

Genus SCENIDIUM, Hall.

(See Plate VII, figs. 29–35.

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Orthis (Scenidium ??) Merope, Billings.

Fig. 31. A view from the brachial valve; showing the area and foramen of the opposite valve. × 4.

Fig. 32. The interior of the brachial valve; showing the simple cardinal process and the crural plates. The deltidial cavity is thickened transversely, and from its center a low median ridge extends forward. × 4.

Hudson River group. *Cincinnati, Ohio.*

Scenidium Halli, Safford.

Fig. 33. The exterior of the pedicle-valve; showing the elevation of the beak. × 4.

Fig. 34. A cardinal view of the same specimen; showing the area and open delthyrium on both valves, with the slender process in the bottom of the brachial delthyrium. × 4.

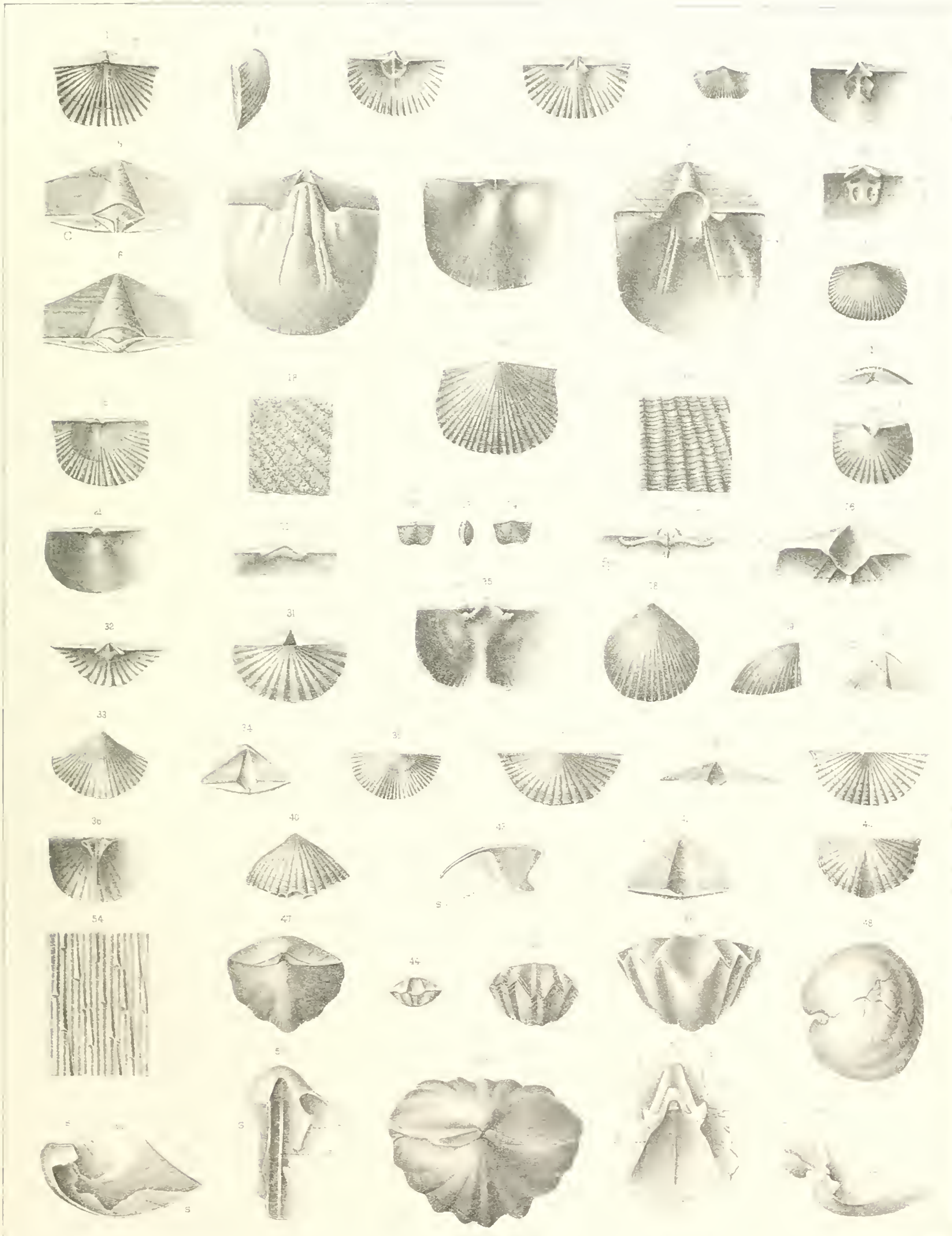
Fig. 35. The exterior of the brachial valve of the same specimen. × 4.

Fig. 36. The interior of a brachial valve; showing the triangular hinge-plate resting on the bottom of the valve, and the low median septum extending beyond the middle of the shell.

The outline of the valve is more elongate than in the preceding specimen. × 4.

Trenton limestone. ("Glade Limestone" of Safford.) *Nashville, Tennessee.*

BRACHIOPODA.



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SCENIDIUM HALLI, Safford, VARIETY.

Figs. 37, 38, 39. Three views of a specimen; showing the great length of the hinge, the relatively low and narrow cardinal areas and the somewhat coarser plications of the surface. × 6.

Trenton horizon. *Cannon Falls, Minnesota.*

SCENIDIUM PYRAMIDALE, Hall.

(See Plate VII, figs. 29, 30.)

Fig. 40. A view of the pedicle-valve; showing its elevation and the character of the surface plications. × 5.

Fig. 41. A cardinal view of the same specimen; showing the concave delthyrial plate or spondylium. × 5.

Fig. 42. A brachial valve of the same specimen. × 5.

Niagara group. *Lockport, N. Y.*

SCENIDIUM AREOLA, Quenstedt.

Fig. 43. A longitudinal section of the two valves; showing the extension of the median plate into the cavity of the pedicle-valve. (After DAVIDSON.)

See for further information, Zeitschr. der deutsch. geolog. Gesellsch., vol. xxiii, plate viii; and DAVIDSON, Devonian Brachiopoda, Suppl., plate iii, figs. 11–14.

GENUS ENTELETES, FISHER DE WALDHEIM.

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ENTELETES HEMIPLICATA, Hall.

Fig. 44. An exterior view of a young individual in which the radial plications are rudimentary.

Fig. 45. A similar view of a small example which bears a plication in the median sinus of the pedicle-valve, with a corresponding furrow on the fold of the opposite valve.

Upper Coal Measures. *Kansas City, Missouri.*

Fig. 46. A similar view of a mature individual; showing the usual character of the surface.

Upper Coal Measures. *Winterset, Iowa.*

Fig. 47. A cardinal view of an individual; showing the area and delthyrium of the pedicle-valve and the relative convexity of the two valves.

Fig. 48. A profile of a very gibbous old individual.

Upper Coal Measures. *Kansas City, Missouri.*

Fig. 49. A profile of the rostral portion of a pedicle-valve; showing the great elevation of the median and lateral septa, the edges of which are more or less broken. × 3.

Fig. 50. A front view of the same specimen; showing the position of the septa, of which the two outer ones limit the area of muscular insertion. × 3.

Fig. 51. The interior of the rostral portion of two valves in articulation. The median septum of the upper or pedicle-valve is broken off, but the lateral septa are retained. In the brachial valve are seen the high crural plates which are produced into strongly recurved crura. At (j) is the small, lobate cardinal process, and in the bottom of the valve a low median ridge. × 2.

Fig. 52. A profile of the same specimen; showing the articulation of the valves and elevation of the crura. × 2.

Upper Coal Measures. *Winterset, Iowa.*

ENTELETES LAMARCKI, Fischer de Waldheim.

Fig. 53. A cardinal view of an individual; showing the area and delthyrium of the pedicle-valve.

Fig. 54. An enlargement of the fine striæ of the surface, which are shown to be tubular, as in RHIPIDOMELLA and SCHIZOPHORIA.

Upper Carboniferous limestone. *Mjatschkowa, Russia.*

For further illustration of this genus, see WAAGEN, Salt-Range Fossils, vol. i, pt. 4; also, MEEK, U. S. Geological Survey, Final Report on Nebraska, pp. 177, 178, plates vi and viii.

PLATE VIII.

(Figures 1–18, 22–31 by R. P. WHITFIELD; 20, 21 by F. J. SWINTON; 19 by G. B. SIMPSON.)

Legend. D. Deltidium, pedicle-valve.
C. Deltidium, brachial valve.
Δ. Delthyrium.
F. Foramen.
F′. Groove on delthyrium, brachial valve.
A. Cardinal area:
a. Inner portion.
a′. Outer portion.
b. Dental sockets.
t. Teeth.
j. Cardinal process.
a. Adductor scars.
r. Anterior diductor scars.
r′. Posterior diductor scars.

GENUS RAFINESQUINA, GEN. NOV.

(See Plate VIII, figs. 1–11; Plate IXA, figs. 1, 2, 4; and Plate XVA, figs. 37–39.)
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RAFINESQUINA INCRASSATA, Safford* (not Hall).

Fig. 1. A view of the brachial valve of a large individual; showing the area and open delthyrium of the pedicle-valve.

Fig. 2. The interior of the brachial valve; showing the structure of the articulating apparatus and the muscular impressions.

Fig. 3. A posterior view of the same specimen; showing the bifurcate, incisor-shaped cardinal process, its surface sloping backward to the hinge-line, and partially covered by the deltidium. × 3.

Fig. 4. A cardinal view of a portion of the hinge and area; showing the deltidia of both valves, that of the pedicle-valve having its surface distinctly grooved. × 3.

Fig. 5. The internal cast of a pedicle-valve; showing the great size of the diductor scars, and the filling of the foramen.

Trenton horizon. *Platteville, Wisconsin.*

RAFINESQUINA ALTERNATA, Conrad.

Figs. 6, 7. Two views of a specimen presenting normal external characters.

Fig. 8. An enlargement of a portion of the hinge-area; showing the deltidia of both valves, and the retention of the foramen at maturity. × 3.

Fig. 9. The interior of a brachial valve; showing the structure of the cardinal process and the adductor scars.

Fig. 10. The interior of a pedicle-valve; showing the flabellate diductor and the narrow adductor scars.

Fig. 11. A posterior view of the articulating apparatus of the brachial valve. The incisor-shaped branches of the cardinal process are widely divergent, and at the bottom of the bifurcation lies a narrow callosity. The deltidium is well developed but not grooved in the middle, and the dental sockets are deeply marked. × 3.

Hudson River group. *Cincinnati, Ohio.*

For other illustrations, see Palæontology of Ohio, Vol. 1, plate vii, figs. 1–3; and Palæontology of New York, Vol. I, plates xxxi and xxxi A.

GENUS LEPTÆNA, DALMAN.

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LEPTÆNA TENUISTRIATA Sowerby (= *L. rhomboidalis*, Wilckens).

Fig. 12. The interior of a brachial valve.

Figs. 13, 14. Views of opposite sides of an individual in which the foramen is retained.

Hudson River group. *Oxford, Ohio.*

Fig. 15. A portion of the hinge of a mature individual, enlarged; showing the foramen situated in front of the area, the slight development of the deltidium of the pedicle-valve, and the great size of that of the brachial valve, the latter being deeply grooved. × 3.

Hudson River group. *Lebanon, Ohio.*

Fig. 16. An enlarged cardinal view of the central portion of the brachial valve; showing the deep groove or central depression, the callosity conforming to the contour of the cardinal apophyses.

Hudson River group. *Oxford, Ohio.*

* Since the true generic relations of the Chazy species, according to the present arrangement, is not fully ascertained, this specific name is retained for the Trenton species. Should the original *Leptæna incrassata*, of the Chazy, prove to be a RAFINESQUINA, the Trenton form will retain the name of *R. Minnesotensis*, N. H. Winchell.

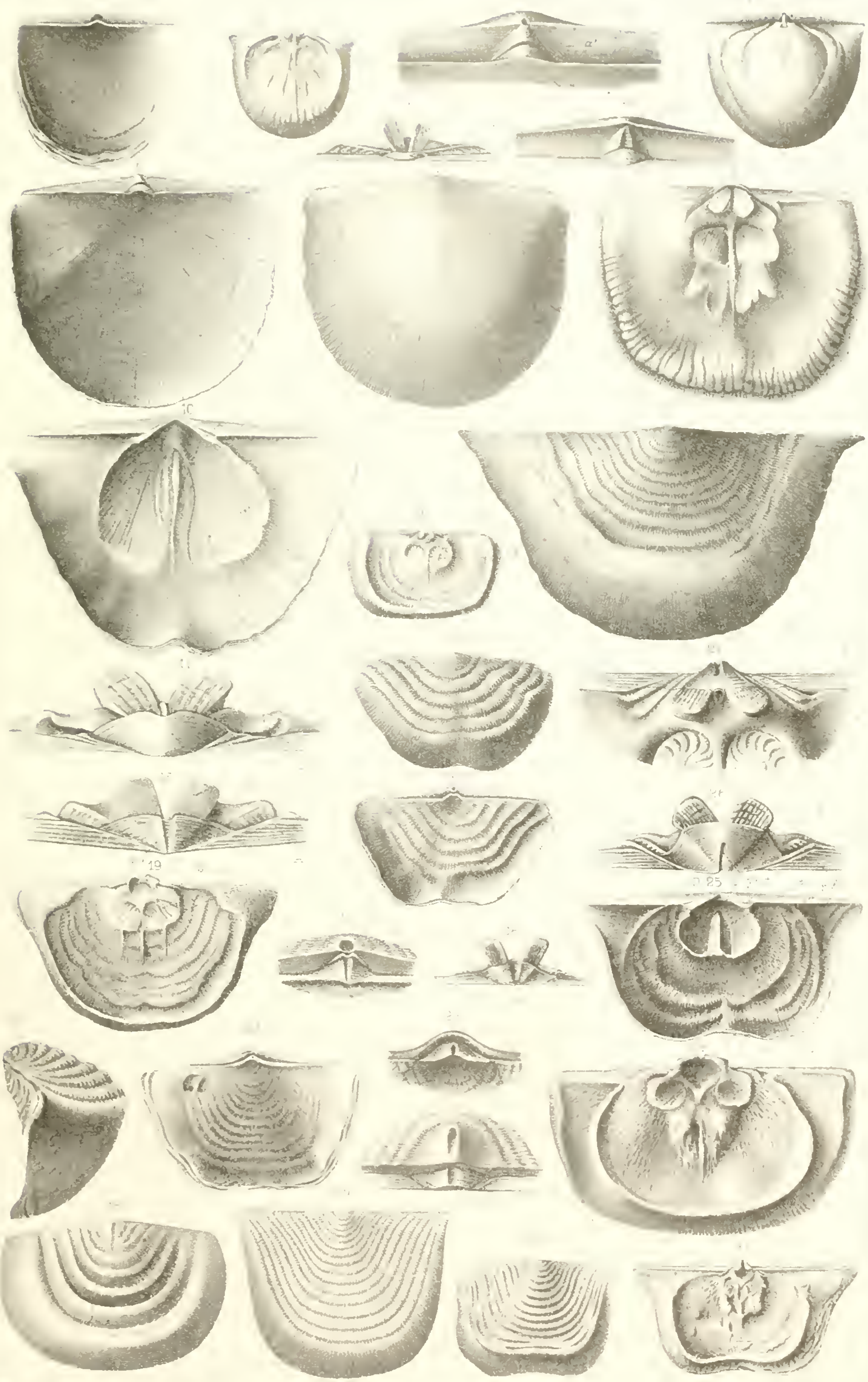

PLATE VIII—Continued.

LEPTÆNA RHOMBOIDALIS, Wilckens.

Fig. 17. The exterior of a large pedicle-valve, which is unusually extended on the hinge-line and with acute cardinal extremities.

Niagara group. *Lockport, N. Y.*

Fig. 18. An enlargement of the articulating apparatus of the brachial valve; showing the central groove of the deltidial callosity, the lobes of the cardinal process, and the dental sockets with their low, thick inner walls (crural plates). × 3.

Fig. 19. The interior of a brachial valve.

Niagara group. *Waldron, Indiana.*

Fig. 20. A view of the brachial valve; showing a foramen in the beak.

Fig. 21. A profile view of a strongly geniculated specimen; showing the contour of the two valves.

Fig. 22. An enlargement of the beaks of an old individual; showing the great obliquity of the foramen in the pedicle-valve, which penetrates the substance of the shell at a considerable distance in advance of the apex; and also the perforation in the deltidium of the opposite valve.

Fig. 23. A cardinal view of a specimen where the deltidium of the pedicle-valve has been lost or absorbed and the space filled by the callosity of the opposite valve which is perforated at the apex.

Fig. 24. The interior of a brachial valve; showing the aspect of the cardinal process from this point of view, the character of the muscular scars, and the strong ridge at the line of geniculation of the valve.

Fig. 25. The interior of a pedicle-valve; showing the character of the muscular impressions.

Fig. 26. An enlargement of the central cardinal portion of a brachial valve; showing the deltidial callus, and the slit formed by the receding or wearing of the apical perforation.

Fig. 27. An enlargement of the interior of the preceding specimen; showing the same features, and also the tubular opening into the rostral cavity between the divisions of the cardinal process.

Lower Helderberg group. *Albany and Schoharie counties, N. Y.*

Fig. 28. The exterior of an exfoliated pedicle-valve; showing very strong undulations and the groove left by the receding of the apical foramen.

Fig. 29. The exterior of a pedicle-valve, in which the undulations are finer and much more numerous than usual. (The *L. undulata* of VANUXEM.)

Corniferous limestone. *Western New York.*

Fig. 30. The exterior of a pedicle-valve.

Fig. 31. The interior of a brachial valve.

Waverly group. *Mallets' Creek, Ohio.*

PLATE IX.

(Figures 1-34, 36 by R. P. WHITFIELD; 35 by F. J. SWINTON, *emend.*)

Legend. A. Cardinal area, pedicle-valve.
a. Inner division.
a′. Outer division.
D. Deltidium, pedicle-valve.
C. Deltidium, brachial valve.
j. Cardinal process.
b. Dental sockets.
s. Median septum.
x. Cardinal area, brachial valve.
t. Teeth.
a. Adductor scars.
r. Didnctor scars.

GENUS STROPHOMENA, RAFINESQUE.

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STROPHOMENA FILITEXTA, Hall.

(See Plate XIA, fig. 3.)

Fig. 1. A view from the brachial valve of a large individual.
Trenton limestone. *Eastern New York.*

Fig. 2. A view of the pedicle-valve; showing the great concavity of the pallial region.
Trenton horizon. *Mineral Point, Wisconsin.*

Fig. 3. The interior of a large brachial valve; showing the cardinal process, crural plates and undefined muscular impression.
Trenton horizon. *Platteville, Wisconsin.*

Fig. 4. The interior of the pedicle-valve of fig. 2; showing the covered delthyrium and the character of the muscular impressions.

Fig. 5. The interior of a larger pedicle-valve.
Trenton horizon. *Mineral Point, Wisconsin.*

Figs. 6, 7. Enlargements of the external (fig. 6) and internal (fig. 7) surface striæ.

For other illustrations, see Palæontology of New York, Vol. I, pl. xxxi B, fig. 3; and Palæontology of Ohio, Vol. I, pl. vi, fig. 5.

STROPHOMENA SULCATA, de Verneuil.

Fig. 8. A view of the brachial valve; showing the area and deltidium of the opposite valve.

Fig. 9. A front view, to show the sinuate anterior margin.
Hudson River group. *Ohio.*

For other illustrations, see Palæontology of Ohio, Vol. I, plate v, fig. 5.

STROPHOMENA NUTANS, James (Meek).

(See Plate IXA, figs. 5-7.)

Fig. 11. A cardinal view of conjoined valves; showing the area and deltidia.
Hudson River group. *Lebanon, Ohio.*

For other illustrations, see Palæontology of Ohio, Vol. I, plate vi, fig. 1.

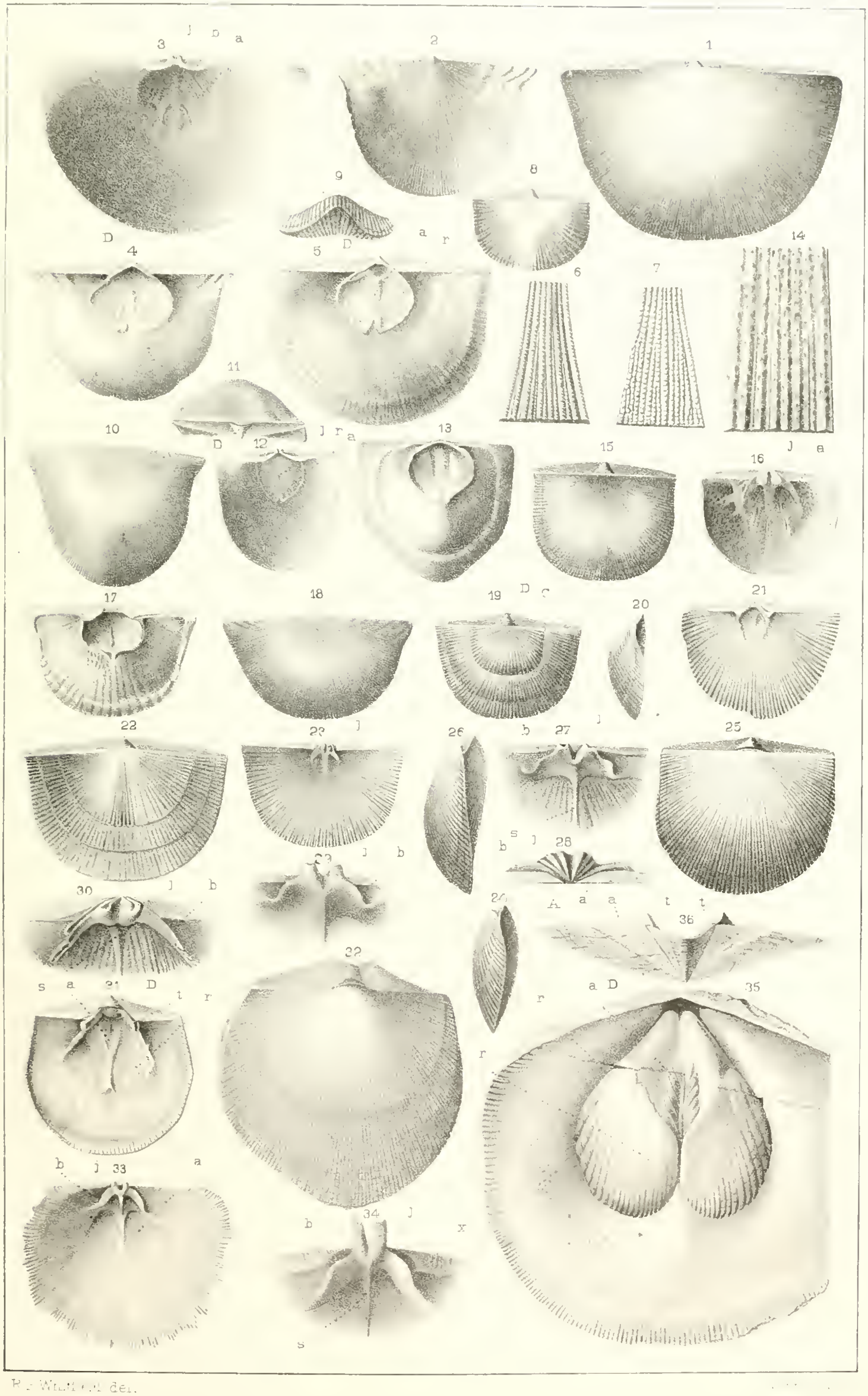
STROPHOMENA WINCHELLI, sp. nov.

Fig. 10. The exterior of the brachial valve; showing its great convexity and the fine filiform radial striæ of the surface.
Trenton limestone. *Clifton, Wisconsin.*

Fig. 12. The interior of a brachial valve; showing the slender bilobed cardinal process and the crural plates, very slightly divergent from the hinge-line. The muscular area is quadrilobate, the posterior scars being broader and having a faintly dendritic surface, the anterior pair being narrow and elongate, and striated close to the median line. The figure gives an inaccurate idea of the structure of the muscular area, which is correctly shown in figure 26, plate xx.
Trenton limestone. *Janesville, Wisconsin.*

Fig. 13. The interior of a pedicle-valve; showing the character of the muscular area, and the thickening about the margins of the shell.
Trenton limestone. *Clifton, Wisconsin.*

Fig. 14. An enlargement of a somewhat exfoliated surface; showing the distribution of punctæ.



R. P. Whitfield del.

STROPHOMENA PLANUMBONA, Hall, = *Strophomena rugosa*, Rafinesque (de Blainville).

Fig. 15. A view of the brachial valve; showing the usual form and proportions of the species.

Fig. 16. The interior of a brachial valve. On account of the great convexity of this valve, the cardinal process is projected upward at an unusual angle.

Fig. 17. The interior of a pedicle-valve; showing the usual character of the muscular markings.

Hudson River group. *Lebanon, Ohio.*

For other illustrations, see Palæontology of New York, Vol. I, plate xxxi B, fig. 4; Palæontology of Ohio, pl. vi, fig. 3; and this volume, plate ix A.

STROPHOMENA SUBTENTA, Conrad.

Fig. 18. The exterior of a brachial valve; showing the oblique wrinkling of the shell about the cardinal extremities, as frequently observed in *S. filitexta.*

Trenton limestone. *Wisconsin.*

STROPHOMENA PLANOCONVEXA, Hall.

Fig. 19. A view of the brachial valve; showing the general external characters of the species.

Fig. 20. A profile; showing the reversed convexity of the shell.

Hudson River group. *Cincinnati, Ohio.*

For other illustrations, see Palæontology of Ohio, Vol. I, plate vi, fig. 2.

GENUS ORTHOTHETES, PANDER.

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ORTHOTHETES SUBPLANA, Conrad.

(See Plate IXA, fig. 19.)

Fig. 21. The interior of a pedicle-valve; showing the muscular impressions.

Niagara group. *Lockport, N. Y.*

Fig. 22. A view of the brachial valve of an old example; showing the area and deltidium of the opposite valve.

Fig. 23. The interior of the brachial valve; showing the character of the cardinal process, the short, abruptly terminating crural plates, and the edge of the deltidium which is very highly developed on this valve.

Fig. 24. A profile; showing the subequally convex valves.

Niagara group. *Waldron, Indiana.*

For other illustrations, see Palæontology of New York, Vol. II, plate liii; and Twenty-eighth Report on the New York State Museum, plate xxi.

ORTHOTHETES WOOLWORTHANA, Hall.

Fig. 25. A view of the brachial valve; showing the general form of the shell and the area and deltidium of the opposite valve.

Fig. 26. A profile of the same specimen.

Fig. 27. An enlargement of the cardinal process; showing its bilobed character from this point of view, and the high crural plates ending abruptly at the crural bases. × 3.

Fig. 28. A posterior view of the same parts; showing the lobation of each branch of the cardinal process, and the additional lobes on each side between the process and the dental sockets, thus making the posterior face of the divaricating process appear six-lobed. × 3.

Fig. 29. Another anterior view of the cardinal process, in which the lobes are rather more prominent and the crural bases less pronounced. × 3.

Fig. 31. The interior of a pedicle-valve; showing the deltidium and muscular impressions.

Lower Helderberg group. *Near Clarksville, N. Y.*

ORTHOTHETES CHEMUNGENSIS, Conrad, var. PANDORA, Billings.

Fig. 30. An enlargement of the hinge area, cardinal process, crural plates, etc., of the specimen, fig. 3, plate x; placed upon this plate by mistake.

PLATE IX—Continued.

Orthothetes deformis, Hall.

Fig. 32. Front view of an individual retaining both valves.

Lower Helderberg group. *Borst's Mill, Schoharie county, N. Y.*

For illustrations of other species of the genus, see Palæontology of New York, Vol, II. plate xvii. and *ibid.* Vol. IV, plates ix and x; and this volume, plate xx, figs. 8, 9.

Genus HIPPARIONYX, Vanuxem.

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Hipparionyx proximus, Vanuxem.

Fig. 33. The interior of a brachial valve of a young individual; showing the strongly bifurcated process, high vertical crural plates, short median septum, and faint muscular scars.

Oriskany sandstone. *Cumberland, Maryland.*

Fig. 34. The cardinal process and its adjoining parts, as obtained from a gutta-percha impression of a natural cast of the interior; natural size. This figure shows very clearly the almost complete obsolescence of the cardinal area, the marginal crenulations extending nearly to the base of the process.

Fig. 35. A natural cast of the interior of a pedicle-valve; showing the impressions of the adductor and diductor muscles.

Fig. 36. The exterior of the cardinal area of the pedicle-valve; showing the covered delthyrium and the projecting teeth. From a gutta-percha impression.

Oriskany sandstone. *Albany county, N. Y.*

For other illustrations, see Palæontology of New York, Vol. III, plates lxxxix; xc; xci, figs. 4, 5; and plate xv A of this volume.

PLATE IXa.

(Figures 1-27 by R. P. WHITFIELD.)

Legend. D. Deltidium, pedicle-valve.
C. Deltidium, brachial valve.
t. Teeth.
b. Dental sockets.
c. Crural plates.
x. Crural bases.
p. Pedicle muscle.
a′. Anterior adductors.
a. Posterior adductors.
r. Diductors.
v. Vascular sinuses.

GENUS RAFINESQUINA, GEN. NOV.

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RAFINESQUINA DELTOIDEA, Conrad.

Fig. 1. The exterior of a pedicle-valve; showing its regular convexity and deep anterior deflection, the radiating striæ of subequal size, and the concentric corrugations.

Fig. 2. Profile of the same specimen; showing the regular convexity from umbo to anterior margin.

Trenton limestone. *Jacksonburg, N. Y.*

Fig. 4. An impression of the exterior surface of the brachial valve; showing its subtriangular outline as usually developed in this species, and the flattened, scarcely concave circumbonal area.

Trenton limestone. *Middleville, N. Y.*

This figure is from the original specimen used by Mr. CONRAD, and is the subject of the drawing by him reproduced in Palæontology of New York, Vol. I, plate XXXI A, fig. 3*f*. That figure, however, gives the valve a convexity which it does not possess. For further illustration of the species, the other figures on the plate cited may be consulted.

GENUS STROPHOMENA, RAFINESQUE (DE BLAINVILLE).

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STROPHOMENA CONRADI, sp. nov.

Fig. 3. View from the brachial valve; showing the reversed convexity of the valves, and the fasciculate surface striæ without concentric rugæ.

Trenton limestone. *Jacksonburg, N. Y.*

STROPHOMENA NUTANS, James (Meek).

Fig. 5. The exterior of a brachial valve.

Fig. 6. The interior of a pedicle-valve; showing the character of the muscular impressions and vascular markings.

Fig. 7. The central cardinal portion of the brachial valve; showing the bilobed cardinal process, the curved crural plates, and the muscular impressions. × 3.

Hudson River group. *Oxford, Ohio.*

For other illustrations, see Palæontology of Ohio, Vol. I, plate vi, fig. 1.

STROPHOMENA PLANUMBONA, Hall (= *S. rugosa*, Rafinesque).

Fig. 8. An enlargement of the cardinal process and crural plates. × 2.

Fig. 9. The corresponding portion of the opposite valve; showing the irregularly crenulated character of the surface of the teeth. × 2.

Hudson River group. *Oxford, Ohio.*

STROPHOMENA FILITEXTA, Hall.

Fig. 10. The interior of a brachial valve; showing the cardinal process, muscular area, and the elevated median ridges of the vascular system (?).

Hudson River group. *Waynesville, Ohio.*

Fig. 11. The interior of a pedicle-valve; showing the limitation of the muscular area by an elevated border, which is continuous from the dental plates.

Fig. 12. Exterior of a brachial valve; showing the tendency to plication of the surface.

Fig. 13. A cardinal view of a specimen retaining both valves, and showing the resupination of the shell.

Fig. 14. A cardinal view of the specimen illustrated on plate ix, fig. 1.

Trenton limestone. *New York.*

Fig. 15. An enlarged view of the interior of a pedicle-valve; showing the vascular markings, which are rarely seen in this species.

Hudson River group. *Waynesville, Ohio.*

STROPHOMENA? (STROPHONELLA?) PATENTA, Hall.

(The actual relations of this species to STROPHOMENA and STROPHONELLA are not yet fully determined.)

Fig. 16. The interior of a large pedicle-valve; showing the muscular area.

Fig. 17. The exterior of the pedicle-valve.

Fig. 18. The interior of a smaller pedicle-valve.

Clinton group. *Reynale's Basin, N. Y.*

GENUS ORTHOTHETES, PANDER.

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ORTHOTHETES SUBPLANA, Conrad.

(See Plate IX, figs. 21–29.)

Fig. 19. An enlargement of the central cardinal portion of the brachial valve; showing the great development of the deltidial callosity, the rounded, somewhat unequal lobes of the cardinal process, and the thin, abrupt, nearly vertical crural plates. × 3.

Niagara group. *Waldron, Indiana.*

ORTHOTHETES INÆQUALIS,* Hall.

Fig. 20. The interior of a pedicle-valve.

Fig. 21. A small brachial valve; showing a tendency to a fasciculation of the striæ.

Fig. 22. A cardinal view of an internal cast of the brachial valve.

Fig. 23. The interior of a brachial valve. In this figure the lobes of the cardinal process are not sufficiently distinguished from the crural plates.

Waverly group (Kinderhook). *Burlington, Iowa.*

ORTHOTHETES INFLATUS, White and Whitfield.

Fig. 24. A cardinal view of one of the original specimens, which is an internal cast of the brachial valve; showing the impression of the cardinal process and adductor muscles.

Fig. 25. The cardinal process, enlarged from a gutta-percha impression; showing its appearance on the anterior face. The crural bases (x) appear very abrupt at the termination on account of the impression having been taken without the shell being first entirely removed from the matrix.

Waverly group (Kinderhook). *Burlington, Iowa.*

ORTHOTHETES DESIDERATUS, n. sp.

Fig. 26. A view of the brachial valve of an internal cast; showing the muscular impressions.

Fig. 27. A cardinal view of the same specimen.

Waverly group. *Ohio.*

* The reference to this species in the Report of the New York State Geologist for 1882, explanation of plate xi A (= ix A) as *Streptorhynchus æquivalvis*, is erroneous. The shell is the *Orthis inequalis*, Hall, Geol. Rep. of Iowa, p. 490, plate ii, figs. 6, a, b, c.

BRACHIOPODA.

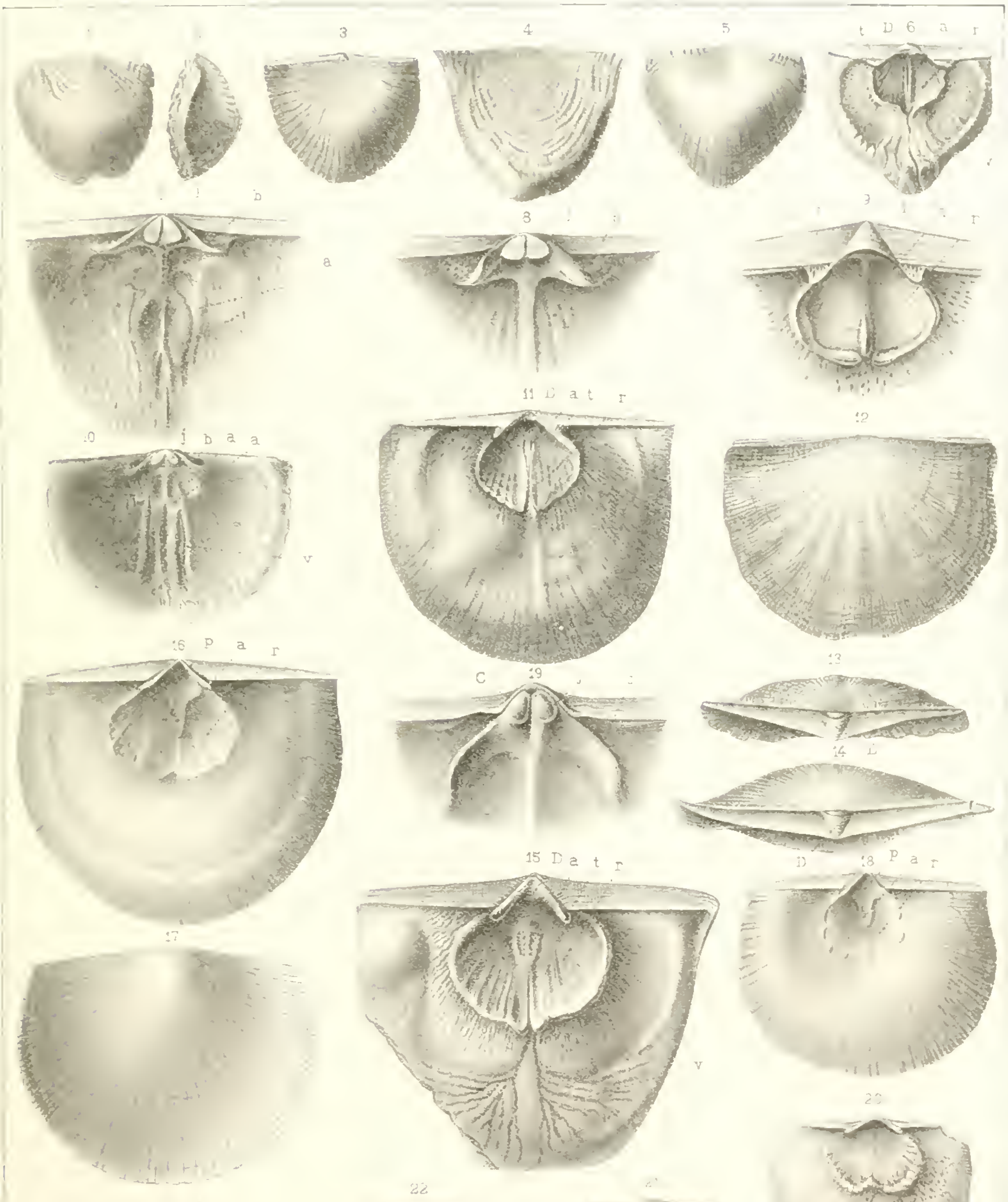

PLATE X.

(Figures 1-14, 16, 18-23 by R. P. Whitfield; 15, 17 by F. B. Meek.)

Legend. D. Deltidium.
A. Cardinal area.
l. Umbo-lateral slopes.
t. Teeth.
d. Dental lamellæ.
b. Dental sockets.
j. Cardinal process.
c. Crura.
s. Median septum.
a. Adductor scars.
r. Diductor scars.

Genus ORTHOTHETES, Fischer de Waldheim.

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Orthothetes Chemungensis, Conrad, var. Pandora, Billings.

Fig. 1. A view from the brachial valve; showing the cardinal area and deltidium of the opposite valve.
Corniferous limestone. *Caledonia, N. Y.*

Fig. 2. The interior of a brachial valve, drawn from a gutta-percha impression; showing the muscular area, and, imperfectly, the cardinal process.
Schoharie grit. *Schoharie, N. Y.*

Fig. 3. The interior of a larger brachial valve; showing with more accuracy the crural plates and the adductor scars.
Plate IX, Fig. 30.—An enlargement of a part of the hinge area, the cardinal process, crural plates and muscular impressions of the preceding specimen.

Fig. 4. The interior of a pedicle-valve; showing the low deltidium, with unsupported teeth, the adductor and diductor scars.
Corniferous limestone. *Caledonia, N. Y.*

Fig. 5. The interior of a pedicle-valve, drawn from a gutta-percha impression.
Schoharie grit. *Schoharie, N. Y.*

Fig. 6. An internal cast of the pedicle-valve; showing the flabellate diductors and the impression of a broad median ridge.
Corniferous limestone. *Western New York.*

Orthothetes Chemungensis, Conrad, var. alternata, Hall.

Fig. 7. The interior of the brachial valve; showing the characteristic cardinal process.
Hamilton group. *Canandaigua Lake, N. Y.*

Orthothetes Chemungensis, Conrad, var. arctostriata, Hall.

Fig. 8. An internal cast of the pedicle-valve; showing the impression left by the rather unusual development of the ridges surrounding the adductor scars and uniting in the median line separating the diductors. This ridge is not a septum but merely the thickening of the edges of the muscular scars. × 2.
Hamilton group. *Western New York.*

Orthothetes Chemungensis, Conrad.

Fig. 9. A cardinal view of a specimen; showing the irregular form of the shell, the usual width of the area, and the character of the deltidium.
Chemung group. *South-western New York.*

For further illustration, see Palæontology of New York, Volume IV, plates ix and x.

Genus DERBYA, Waagen.

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Derbya crassa, Meek and Hayden.

Fig. 10. The interior of a brachial valve; showing the cardinal process and muscular impressions. The former is represented as having the lobes upon its edge and too acutely angular.

Fig. 11. The interior of a pedicle-valve, with strong median septum dividing the muscular area, and highly developed teeth projecting into the cavity of the valve.
Coal Measures. *Near Winterset, Iowa.*

PLATE X—Continued.

Derbya robusta, Hall.

Fig. 12. The exterior of a compressed brachial valve, in which the radial striæ of the shell are strongly developed.

Fig. 13. An enlargement of the cardinal process from another specimen.

Figs. 14 [17 in error], 15. Profile and brachial views of a large individual; showing the external characters of the species.

Fig. 16. The interior of the cardinal portion of the pedicle-valve; showing the character of the muscular scars, the strong but short median septum, projecting teeth and the convex deltidium. The projecting tooth on the right-hand side of the figure has become double from abnormal growth.

Fig. 17. The exterior of a pedicle-valve; showing the character of the striæ, which differ in some degree from their uniformity shown in the specimen represented in figs. 14 and 15.

Coal Measures. *St. Clair county, Illinois.*

For other illustrations, see Palæontology of Eastern Nebraska, plates v and viii.

Genus MEEKELLA, White and St. John.

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Meekella striatocostata, Cox.

Fig. 18. Profile of a specimen retaining both valves; showing the great elevation of the cardinal area of the pedicle-valve.

Fig. 19. Cardinal view of a larger individual; showing the high area, narrow deltidium, and the bases of the crural plates in the brachial valve.

Fig. 20. A view of the pedicle-valve of the same specimen.

Fig. 21. A cardinal view of a specimen from which the apex of the pedicle-valve has been removed to show the dental lamellæ.

Fig. 22. An enlargement of the cardinal process; showing the extreme elevation of the lobes and the crural plates. The central portion of the process is incorrectly represented as having three instead of two lobes.

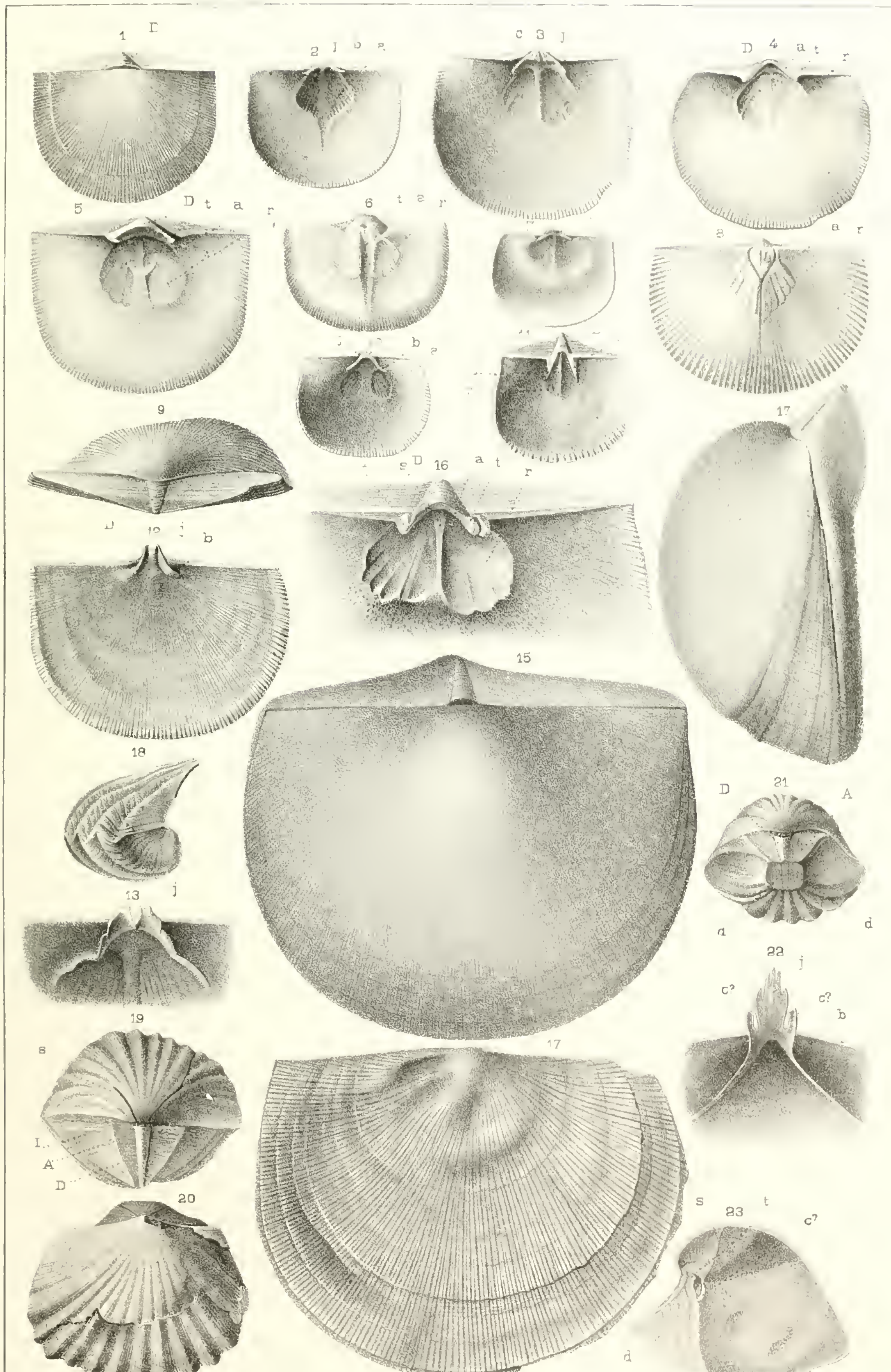
Fig. 23. A longitudinal section of the specimen represented in fig. 19; showing the extent of the dental lamellæ and crural plates, to the latter of which one of the crura is attached.

Coal Measures. *Near Winterset, Iowa.*

For other illustrations, see Transactions of the Chicago Academy of Natural Sciences, Volume I, pp. 120, 121; and Palæontology of Eastern Nebraska, plate v.

BRACHIOPODA.

Generic Illustrations



R.P Whitfield, del.

PLATE XI.

(Figures 1-22 by R. P. WHITFIELD)

Legend. D. Deltidium, pedicle-valve.
C. Deltidium, brachial valve.
t. Teeth.
d. Dental lamellæ.
b. Dental sockets.
c. Crural plates.
s. Median septum.
j. Cardinal process.
r. Diductor scars.
a. Anterior adductors.
a′. Posterior adductors.

GENUS DERBYA, WAAGEN.

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DERBYA KEOKUK, Hall.

Figs. 1, 2. An internal cast and gutta-percha impression of the central cardinal area, viewed from the brachial valve; showing the character and extent of the muscular area, cardinal process, dental lamellæ and median septum.

Keokuk beds (Knobstone group). *New Providence, Indiana.*

Fig. 3. An partial cast of the interior of a pedicle-valve; showing the muscular scars and impression of the median septum.

Keokuk beds. *Keokuk, Iowa.*

DERBYA (?) BILOBA, Hall.*

Fig. 4. A cardinal view; showing the ventricose brachial valve and short area of the pedicle-valve. × 2.

Fig. 5. A view of the brachial valve; showing the bilobed contour of the shell, obdurate outline, the short cardinal area and deltidium of the opposite valve. × 2.

Coal Measures. *Winterset, Iowa.*

STREPTORHYNCHUS, KING.

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STREPTORHYNCHUS HALLIANUS, Derby.

Fig. 6. A view from the brachial valve of an entire shell.

Fig. 7. A posterior view of the cardinal process; showing the lobation of the posterior face, the elevated crural plates and the grooved deltidium. × 2.

Fig. 8. An enlarged view of the same parts, from above; showing also the character of the adductor impressions. × 2.

Fig. 9. The cardinal process of a larger individual; showing the grooving of the extremities of the lobes.

Fig. 10. A profile of the same; showing the backward extension of the process and the great elevation of the crural plates. × 2.

Fig. 11. A posterior view of the same. × 2.

Fig. 12. The cardinal process of another specimen; showing a greater elevation and deeper bifurcation.

Fig. 13. The exterior of an unsymmetrical pedicle-valve; slightly restored about the left ante-lateral margin, and showing the strongly alternating striæ.

Fig. 14. The interior of the same valve; showing the unsupported teeth, and the character of the muscular scars.

Fig. 15. The exterior of a pedicle-valve, having a plicated exterior similar to that of MEEKELLA and *Streptorhynchus pectiniformis*, Davidson. The shell is unsymmetrical and the outline is partially restored.

Fig. 16. The interior of the same specimen; showing the cardinal area, closed delthyrium, the projecting teeth, and the flabellate muscular impression.

Fig. 17. A view looking into the umbonal cavity of the specimen represented in fig. 14; showing the absence of dental lamellæ and median septum.

Upper Carboniferous. *Bomjardim and Itaituba, Province of Pará, Brazil.*

* Report of the New York State Geologist for 1882 (pub. 1883), explanation of plate (xi) 41, figs. 4 and 5.

PLATE XI—Continued.

Genus DERBYA, Waagen.

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Derbya Correana, Derby.

Fig. 18. Cardinal view of an internal cast of the pedicle-valve; showing the cavities left by the dental lamellæ and median septum.

Fig. 19. The same specimen, viewed from above; showing the extent of the median septum.

Fig. 20. Cardinal view of an internal cast having a much higher area and a somewhat distorted beak.

Fig. 21. The exterior of a high cardinal area; showing the longitudinally grooved deltidium perforated near the lower part by a small oval foramen, which is probably accidental. From a gutta-percha impression in a natural mould.

Fig. 22. The interior of a pedicle-valve; showing the union of the dental lamellæ with the median septum, thus forming a subapical vault.

Upper Carboniferous. *Itaituba, Brazil.*

For the original illustrations of the two preceding species, see Bulletin of the Cornell University, Vol. I, No. 2.

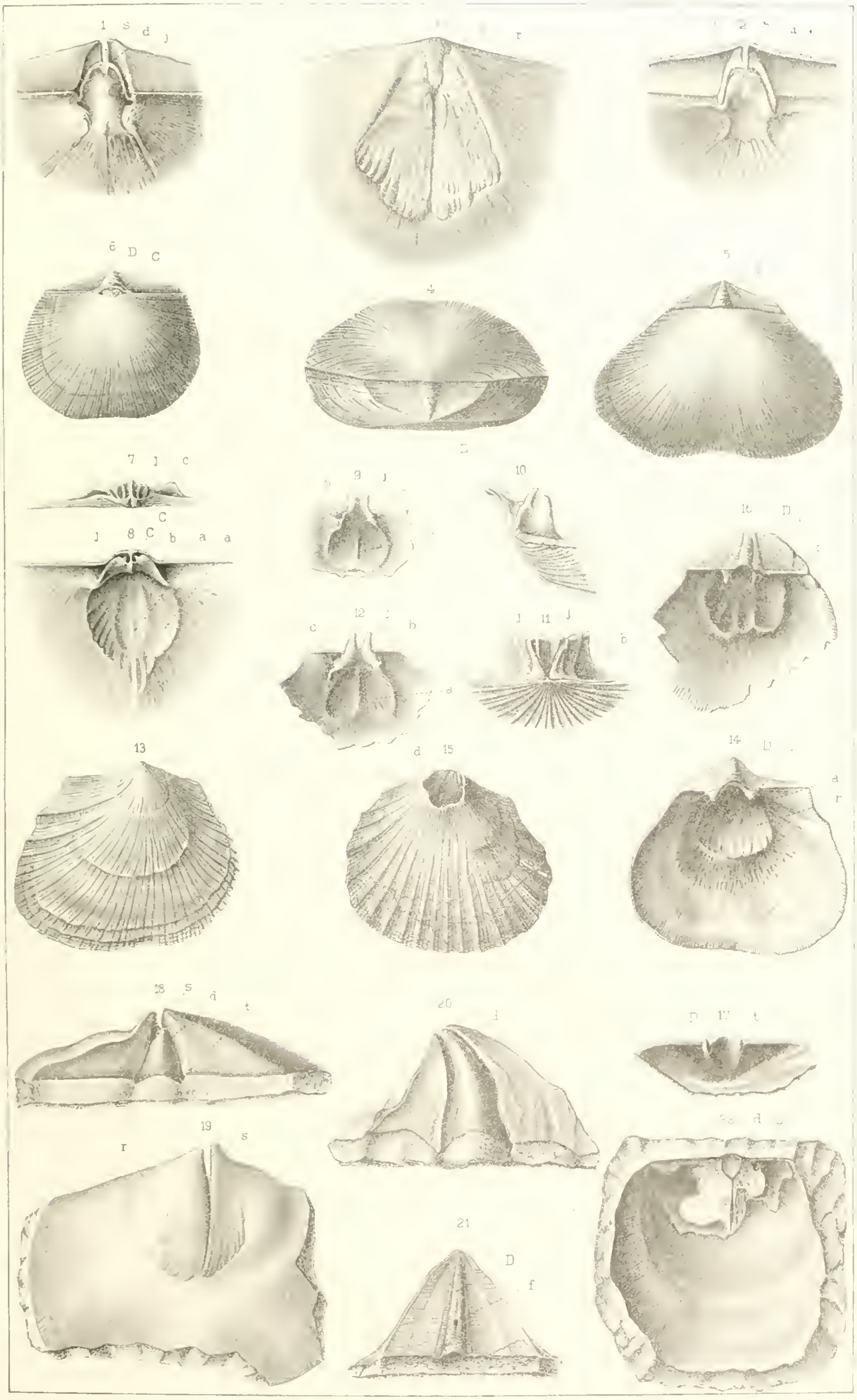

PLATE XIa.

(Figures 1, 2, 4–10, 12–30 by G. B. Simpson; 3 by J. C. McConnell; 11 by E. Emmons.)

Legend.
D. Deltidium.
t. Teeth.
j. Cardinal process.
fp. Crural plates.
b. Dental sockets.
mf. Muscular fulcra.
s. Median septum.
a. Adductor scars.
r. Diductor scars.
x. Cicatrix of attachment.

Genus STROPHOMENA, Rafinesque (de Blainville).

(See Plates IX and IXa.)

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Strophomena Wisconsinensis, Whitfield.

Fig. 1. Cardinal view of a specimen; showing the broad cardinal area and deltidium of the pedicle-valve, the concavity of the brachial valve at its beak and its great convexity over the pallial region.

Fig. 2. Profile of the same specimen; showing the degree of retrorsion in the umbo of the pedicle-valve.

Hudson River group. *Wilmington, Illinois.*

For other illustrations, see Geology of Wisconsin, Vol. IV, plate xii, figs. 11–13.

Strophomena filitexta, Hall.

(See Plate IX, figs. 1–7; and Plate IXa, figs. 10–15.)

Fig. 3. The interior of a brachial valve; showing the articulating apparatus and the lobate vascular (?) ridges extending forward from the impression of the adductor muscles.

Hudson River group. *Richmond, Indiana.*

Strophomena fluctuosa, Billings.

Fig. 4. Profile view; showing the resupination of the lower valve and the great anterior deflection of the shell.

Fig. 5. The cardinal area of the pedicle-valve, enlarged; showing the deltidium, the striated path of growth of the dental ridges, and at (*t*) the pectinated margin of one of the teeth, the other not being well preserved. × 3.

Hudson River group. *Spring Valley, Minnesota.*

Strophomena nutans, James (Meek).

(See Plate IXa, figs. 5–7.)

Fig. 6. The interior of a pedicle-valve.

Fig. 7. Profile of the same specimen; showing the great elevation of the interrupted ridges surrounding the muscular area, and the median thickening on the anterior margin.

Hudson River group. *Weiseburgh, Indiana.*

Strophomena sulcata, de Verneuil.

(See Plate IX, figs. 8, 9.)

Fig. 8. The interior of a brachial valve; showing the peculiar character of the cardinal process, the strong curved crural plates, and the thickened muscular area.

Hudson River group. *Oxford, Ohio.*

Genus ORTHOTHETES, Fischer de Waldheim.

(See Plates IX and IXa.)

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Orthothetes subplana, Conrad.

(See Plate IX, figs. 21–24.)

Fig. 9. Cardinal view of an internal cast; showing the impression of the inner face of the cardinal process.

Niagara group. *Bridgeport, Illinois.*

Fig. 10. The cardinal area of a brachial valve, enlarged. The lobes of the cardinal process are enclosed behind by a well developed deltidium, and the crural plates are short and erect, terminating abruptly. × 3.

Niagara group. *Waldron, Indiana.*

Fig. 11. An internal cast of the brachial valve.

Fig. 12. The cardinal process, enlarged. The lobes are strongly defined, the crural plates short and slightly recurving where they join the bottom of the valve, producing a thickening of the dental sockets. × 3.

Lower Helderberg group. *Albany county, N. Y.*

Orthothetes prava, Hall.

Fig. 13. The interior of a brachial valve retaining the cardinal process, flabellate muscular scars and traces of vascular sinuses.

Upper Devonian. *Hackberry Grove, Iowa.*

Orthothetes Chemungensis, Conrad.

(See Plate X, fig. 9.)

Fig. 14. The cardinal process, enlarged; showing upon its summit the edges of the lobes on the posterior face. The transverse grooves at the junction of the process with the crural plates are made to appear somewhat too abrupt. Frequently the lobes of the cardinal process are more deeply divided than in this specimen. × 2½.

Hamilton group. *Western New York.*

For further illustration, see Palæontology of New York, Volume IV, plates ix and x.

Orthothetes crenistria, (Phillips ?) Meek.

Fig. 15. The cardinal process, enlarged; showing the character of its inner surface and the extent of the crural plates. × 3.

Waverly group. *Sciotoville, Ohio.*

For other illustration, see Palæontology of Ohio, Volume II, plate x, fig. 5.

Orthothetes lens, White.

Fig. 16. The exterior of a pedicle-valve.

Fig. 17. The interior of the same valve; showing area, deltidium, teeth and muscular impressions.

Fig. 18. The exterior of a brachial valve.

Fig. 19. The interior of the same valve: showing cardinal process, muscular impressions and ovarian markings.

Fig. 20. The cardinal process of the same specimen, enlarged to show its structure. Its outer face is covered by the deltidium, which conforms to the grooved surface of the lobes. The crural plates are strongly recurved at their bases about the dental sockets. × 3.

Choteau limestone. *Louisiana, Missouri.*

Fig. 21. A very young pedicle-valve which retains the perforation at the apex of the deltidium. × 8.

Fig. 22. Cardinal view of the same specimen; showing the height of the area and the prominence of the deltidium. × 8.

Choteau limestone. *Pike county, Missouri.*

Genus DERBYA, Waagen.

(See Plates X, XI and XIb.)

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Derbya Broadheadi, sp. nov.

Fig. 23. Cardinal view of an entire, mature individual; showing the rugose and somewhat irregular pedicle-valve, the more symmetrical brachial valve bearing a median sinus.

Fig. 24. Profile view of the same specimen.

Upper Coal Measures. *Kansas City, Missouri.*

Derbya ruginosa, sp. nov.

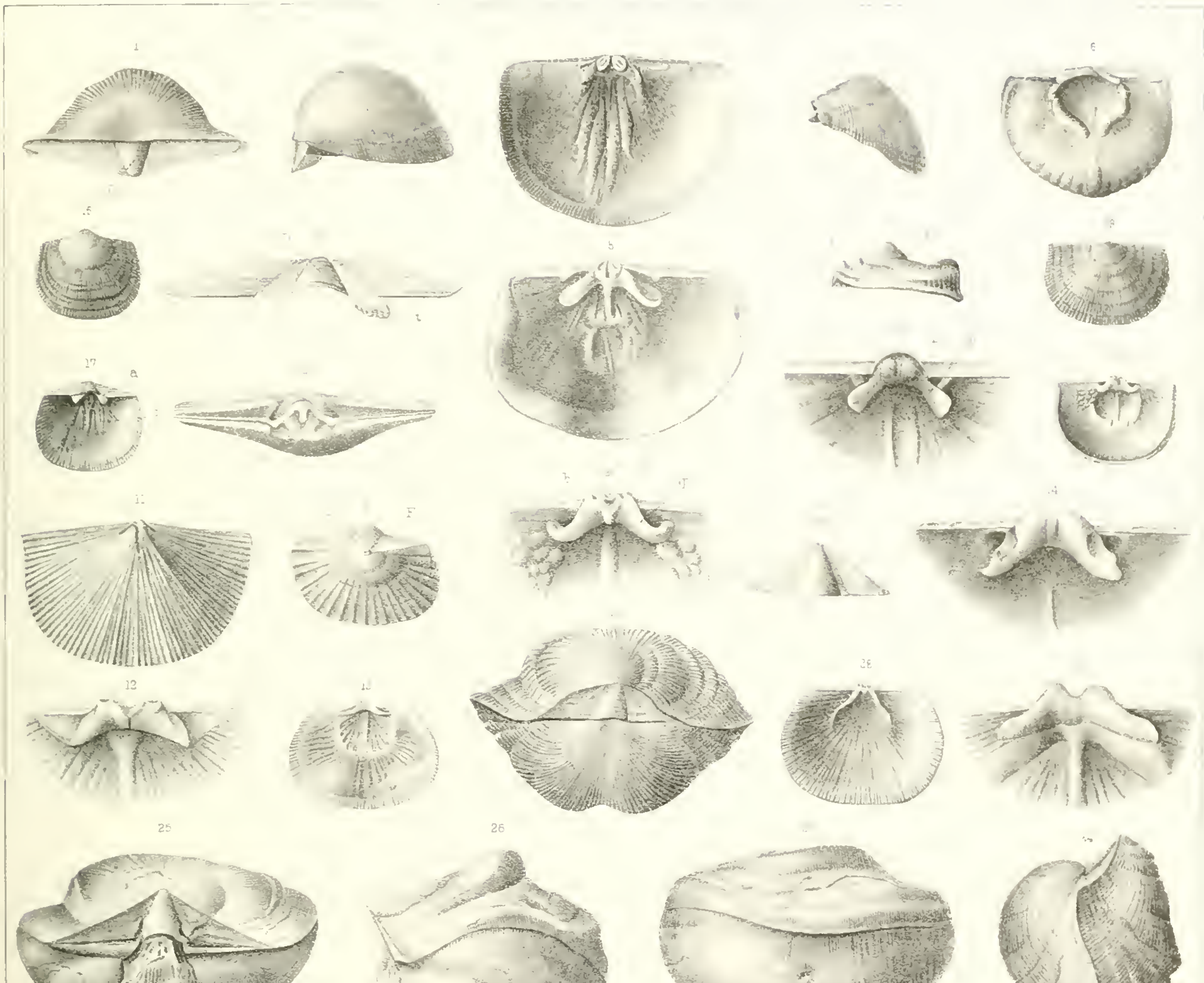
Figs. 25, 26, 27. Three views of an internal cast in chert, retaining portions of the inner laminæ of the shell. Both valves were of irregular growth, the brachial valve not having the median sinus of the preceding species. There are many points of similarity between this fossil and the *Orthis senilis*, Phillips (*Streptorhynchus crenistria*, var. *senilis*, Davidson), which has been shown by Derby to have a septum in the pedicle-valve.

Keokuk limestone. *New Providence, Indiana.*

BRACHIOPODA.

Strophomenidae

Generic Illustrations



G.B. Simpson del.

DERBYA CRASSA, Meek and Hayden.

(See Plate X, figs. 10, 11; and Plate XIB, figs. 23, 24.)

Fig. 28. The interior of a small brachial valve.

Fig. 29. The cardinal process of the same specimen, enlarged; showing the lobation at its summit and the extent of the crural plates. × 3.

Upper Coal Measures. *Kansas City, Missouri.*

Fig. 30. The exterior of a larger pedicle-valve.

Fig. 31. The interior of a small pedicle-valve; showing the median septum and large muscular scars.

Fig. 32. The interior of a large and old pedicle-valve; showing the median septum, the thickening about the muscular area, due to age, and marks of vascular sinuses.

Upper Coal Measures. *Winterset, Iowa.*

Fig. 33. The interior of a large brachial valve which is referred to this species with some doubt. The crural plates are well produced, partially enclosing arborescent scars of the adductor muscles. The valve is unusually convex for one of this species.

Upper Coal Measures. *Kansas City, Missouri.*

For other illustrations, see Palæontology of Eastern Nebraska, plate v, fig. 10, and plate viii, fig. 1.

DERBYA BENNETTI, sp. nov.

Fig. 34. The exterior of a pedicle-valve which retains the scar of attachment at the umbo.

Fig. 35. The opposite side of the same specimen; showing the height of the cardinal area of the pedicle-valve and the median sinus on the brachial valve. A CRANIA is attached to the apex of the latter valve.

Fig. 36. Profile view of another specimen.

Fig. 37. Cardinal view of the same; showing the high cardinal area and the lack of symmetry in the pedicle-valve.

Fig. 38. The same specimen after having the pedicle-valve cut horizontally near the hinge. The section shows the unsupported dental ridges, the tips of the grooved cardinal process, and the extravagant development of the median septum.

Fig. 39. A similar section of the same specimen near the apex. Here the median septum is coalesced with a solid callosity filling the apical portion of the deltidial cavity.

Upper Coal Measures. *Kansas City, Missouri.*

PLATE XI B.

(Figures 2–17, 20–24 by G. B. Simpson; 1, 18, 19 by E. Emmons.)

Legend. j. Cardinal process. rv. Rostral vault.
d. Dental lamellæ. dr. Dental ridges.
t. Teeth.

Genus DERBYA, Waagen.

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(See Plates X, XI and XIa.)

Derbya, sp. indet.

Fig. 1. The interior of a large and very convex brachial valve; showing the cardinal process and short, vertical crural plates, from the base of which a thickened ridge extends about the muscular area. The accompanying outline profile shows the convexity of the valve.

Upper Coal Measures. *Kansas City, Missouri.*

Derbya cymbula, sp. nov.

Fig. 2. Cardinal view of a large individual, somewhat incomplete at the apex; showing the height of the area, the median groove on the surface of the deltidium, and the tendency to irregular growth in the pedicle-valve. The broken surface at the apex of the pedicle-valve shows evidence of the existence of a median septum.

Fig. 3. View of the brachial valve of the same specimen; showing its form, contour and the character of the surface ornamentation.

Figs. 4, 5. Cardinal and profile views of a small individual, probably belonging to the same species. In this specimen the irregular growth is very pronounced in both valves.

Upper Coal Measures. *Near Kansas City, Missouri.*

Derbya Kaskaskiensis, McChesney.

Fig. 6. The interior of an imperfect pedicle-valve, in which the median septum unites with the dental lamellæ, forming an elongate deltidial or rostral vault, like that seen in *Derbya Correana*, Derby (plate xi, fig. 22).

Chester limestone. *Crittenden county, Kentucky.*

Derbya robusta (?), Hall.

(See Plate X, figs. 12–17.)

Fig. 7. The interior of a brachial valve of an old shell, which probably belongs to this species. The cardinal process is much thickened and slightly irregular in its growth, the muscular area deeply excavated but not well defined, and the pallial region covered with traces of the vascular sinuses. The outline at the left shows the convexity of the valve.

Upper Coal Measures. *Winterset, Iowa.*

Fig. 8. The interior of a pedicle-valve, having a comparatively narrow cardinal area, a relatively small flabellate muscular impression, and a short median septum.

Upper Coal Measures. *Near Kansas City, Missouri.*

Genus STREPTORHYNCHUS, King.

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Streptorhynchus pelargonatus, Schlotheim.

Fig. 9. An internal cast of the two valves; showing the position of the deltidium and dental ridges of the pedicle-valve, the inner face of the cardinal process, and the muscular impressions of the brachial valve. × 3.

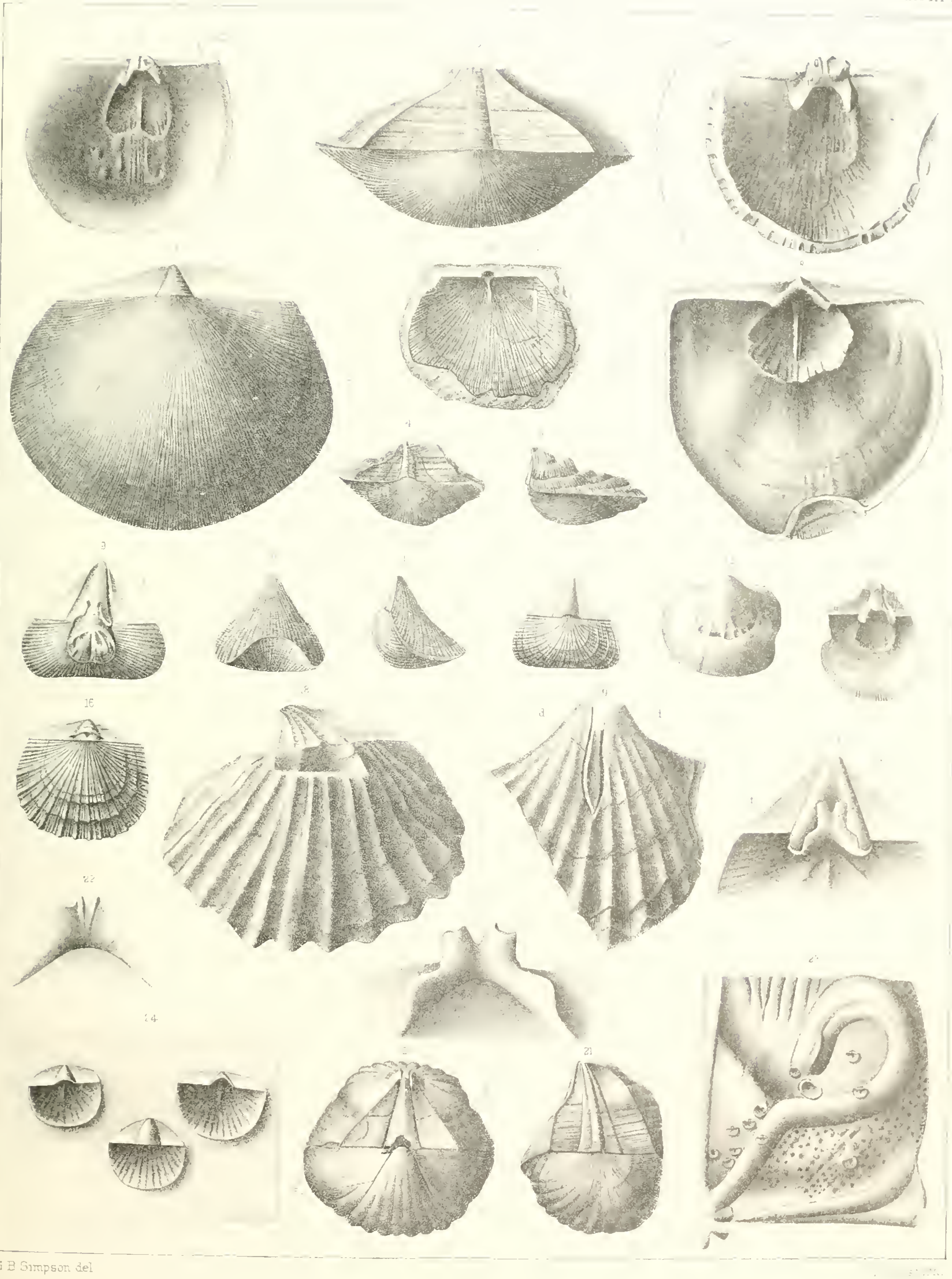
Figs. 10, 11, 12. Anterior, profile and cardinal views of a specimen which retains the shell; showing the contour and general external characters of the species. × 2.

Fig. 13. An internal cast of the pedicle-valve; showing the form of the muscular area, without evidence of a median septum. × 2.

Fig. 14. The interior of the cardinal portion of the articulated valves; showing the dental ridges and inner surface of the deltidium, the cardinal process, crural plates and the character of the articulation. × 5.

Permian Formation. *Pösneck, Silesia.*

For further illustration, see Geinitz, Dyas, plate xvi, figs. 26–34; Davidson, Permian Brachiopoda, plate ii, figs. 32–42.



G B Simpson del

STREPTORHYNCHUS ULRICHI, sp. nov.

Fig. 15. The interior of a pedicle-valve, referred to the genus on account of the peculiar form of the shell and the absence of median septum or dental plates.

Chester limestone. *Crittenden county, Kentucky.*

GENUS DERBYA, WAAGEN.

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DERBYA (?) COSTATULA, sp. nov.

Fig. 16. View from the brachial valve of a small specimen, which shows the characteristic surface ornamentation of this species. This consists of strong radial ribs alternating with fascicles of two, three or four finer striæ. × 2.

Fig. 17. The cardinal process of a brachial valve similar in external characters to that of the preceding specimen. × 3.

Chester limestone. *Crittenden county, Kentucky.*

GENUS MEEKELLA, WHITE AND ST. JOHN.

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(See Plate X, figs. 18–23.)

MEEKELLA OCCIDENTALIS, Newberry.

Fig. 18. View of the brachial valve of an internal cast which retains a portion of the shell over the cardinal area of the pedicle-valve. The deltidium of this area shows the same structure as in the following species and in the genus TRIPLECIA, a considerable portion of the covering between the dental ridges being flat or slightly concave, the convex ridge being confined to the middle of the plate. The apex of the brachial valve is removed, showing (imperfectly in the figure) the basal portion of the inner surface of the cardinal process.

Fig. 19. An incomplete internal cast of the pedicle-valve; showing the extension and convergence of the dental lamellæ and the fine radial lines upon the surface of the plications.

Both figures are from the original specimen of *Orthisina occidentalis*, Newberry.

Upper Carboniferous limestone. *Cañon of Diamond River.*

MEEKELLA STRIATOCOSTATA, Cox.

(See Plate X. figs. 18–23.)

Fig. 20. Cardinal view of a large, symmetrical individual, essentially an internal cast in chert; showing the position of the dental and crural plates.

Upper Coal Measures. *Winterset, Iowa.*

Fig. 21. Cardinal view of a distorted specimen, with an unusually high cardinal area.

Fig. 22. The form of the cardinal process, from a gutta-percha impression of a natural mould. × 3.

Upper Coal Measures. *Lawrence county, Kansas.*

GENUS DERBYA, WAAGEN.

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(See Plates X, XI and XIA.)

DERBYA CRASSA, Meek and Hayden (?).

(See Plate X, figs. 10, 11; and Plate XIA, figs. 28–33.)

Fig. 23. A portion of the internal surface of the brachial valve of *Productus Nebrascensis*, to which are attached several minute pedicle-valves, some of which show the presence of a broad cardinal area, deltidium and a median septum. It will be observed that most of the attached shells have their hinge-lines parallel to that of the PRODUCTUS, though their relative positions are inverted. × 3.

Fig. 24. A further enlargement of three of these shells; showing all the details of structure that are retained. These attached valves seem to be the young of some streptorhynchoid species having a median septum in the pedicle-valve, and as *Derbya crassa* is the most abundant of these forms in the associated fauna, the fossils may be tentatively referred to this species. × 10.

Upper Coal Measures. *Near Kansas City, Missouri.*

PLATE XIc.

(Figures 1-3, 5-9, 13, 14, 17, 18, 20-22 by R. P. Whitfield; 4, 10-12, 15, 16, 19, 25-28 by E. Emmons; 23, 24 by C. E. Beecher; 29-39 copies.)

Legend. F. Foramen.
ps. Deltidium.
c. Crura.
j. Cardinal process.
d. Dental lamellæ.
a. Anterior adductors.
a′. Posterior adductors.
r. Diductors.

Genus TRIPLECIA, Hall.

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Triplecia extans, Emmons.

Fig. 1. The brachial valve of an individual of average dimensions.

Fig. 2. An anterior view of the same.

Fig. 3. A cardinal view of the same. The delthyrium, which is here represented as open, is obscured in the specimen.

Trenton limestone. *Lowville, N. Y.*

Fig. 4. The cardinal area of the pedicle-valve; showing the apical foramen and the convex deltidial covering.

Trenton limestone. *Carlton Island, N. Y.*

Fig. 5. A cardinal view of a brachial valve; showing the bifurcated cardinal process extending into the matrix.

Figs. 6, 7. Anterior and posterior views of a normal individual, the latter showing the impressions of the dental plates of the pedicle-valve. × 2.

Trenton limestone. *Middleville, N. Y.*

Triplecia nucleus, Hall.

Figs. 8, 9. Cardinal and profile views of a normal individual, the former showing the foramen and deltidium of the pedicle-valve. × 2.

Trenton limestone. *Middleville, N. Y.*

Triplecia spiriferoides, McCoy.

Fig. 10. An internal cast of the brachial valve.

Fig. 11. A cardinal view of the same specimen; showing the impressions of the crura (*c*) and of the bifurcated cardinal process.

Caradoc sandstone. *North Wales.*

Triplecia Ortoni, Meek.

Fig. 12. The interior of the pedicle-valve; showing the narrow area and much thickened teeth.

Fig. 13. The exterior of a brachial valve.

Fig. 14. Cardinal view of a specimen having the valves in conjunction; showing the cardinal area, foramen and deltidium.

Fig. 15. Interior of the cardinal region of conjoined valves; showing their mode of articulation.

Fig. 16. Profile of the apical portion of the brachial valve; showing the curvature of the cardinal process.

Fig. 17. The central cardinal portion of an old and thickened brachial valve. The tips of the cardinal process and of one of the crura have been broken.

Fig. 18. The external cardinal area of conjoined valves. × 3.

Fig. 19. Posterior view of the cardinal process; showing the grooves on the outer face of its branches.

Fig. 20. Inner view of the same feature in a younger shell.

Clinton group. *Dayton, Ohio.*

For other illustrations, see Palæontology of Ohio, Volume I, plate xv, figs. 1 *a–k*.

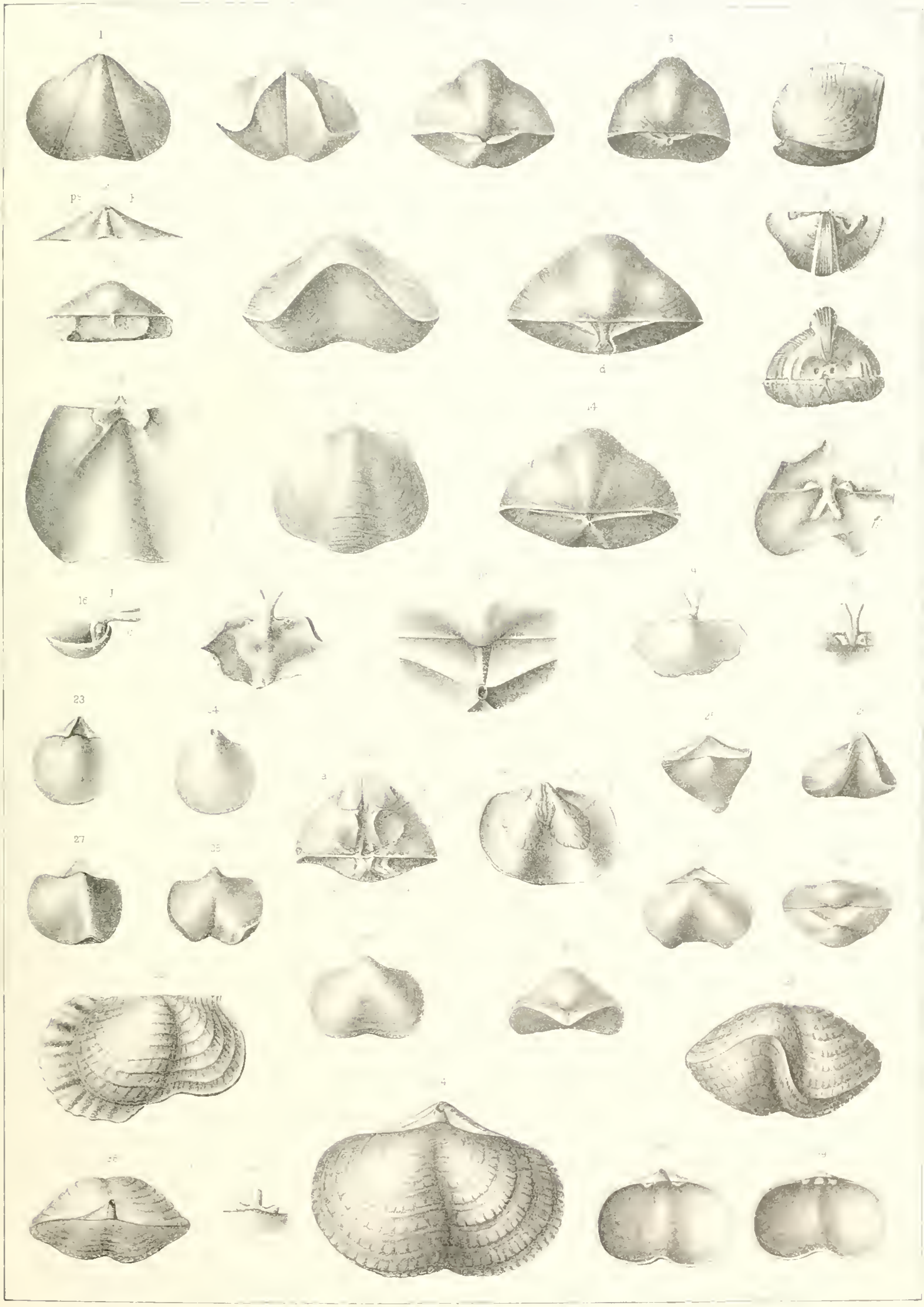
Triplecia insularis, Eichwald.

Fig. 21. Posterior view of an internal cast of the conjoined valves; showing, in the brachial valve, the impressions of the antertor and posterior adductors, the crura and cardinal process, and, in the pedicle-valve, the extent of the dental lamellæ.

Caradoc sandstone. *Ty-Isaf, Wales.*

Strophomenidae

Generic Illustrations



TRIPLECIA WENLOCKENSIS, Davidson.

Fig. 22. A cast of the interior of the pedicle-valve; showing the cardinal adductor and diductor muscular scars and the impressions of the dental lamellæ.

Wenlock limestone. *England.*

GENUS MIMULUS, BARRANDE.

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MIMULUS WALDRONENSIS, Miller and Dyer.

Fig. 23. View from the brachial valve of a very young individual. The shell is nearly symmetrical, and shows an open triangular delthyrium, ending in a circular apical foramen. × 5.

Fig. 24. The opposite side of the same specimen. × 5.

(From Memoirs N. Y. State Museum, Volume I, No. 1, plate iii, figs. 9, *9a.*)

Fig. 25. Cardinal view of an adult individual, the type specimen. The cardinal area shows no trace of deltidium or foramen. × 3.

Figs. 26, 27, 28. Other views of the same specimen; showing the peculiar asymmetry of the shell.

Niagara group. *Waldron, Indiana.*

MIMULUS CONTRARIUS, Barrande.

Fig. 29. The exterior of the pedicle-valve; showing the broad median sinus.

Fig. 30. Cardinal view; showing the relative contour of the valves and the faint trace of the deltidium.

Etagé E_2. *Tetin, Bohemia.*

(After BARRANDE, Système Silurien, Vol. V, pl. 9, fig. vi, A, E.)

MIMULUS PERVERSUS, Barrande.

Fig. 31. Dorsal view of the shell; showing the sinus on the brachial valve and the uninterrupted cardinal area of the pedicle-valve.

Fig. 32. Cardinal view of the same specimen.

Etagé E_2. *Listice, Bohemia.*

(After BARRANDE. Système Silurien, Vol. V, pl. 1, fig. iii, C, E.)

GENUS STREPTIS, DAVIDSON.

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STREPTIS GRAYI, Davidson.

Fig. 33. View of a brachial valve which retains the lamellar expansion at one of the growth-lines. × 4.

Etagé E_2. *Lodenitz, Bohemia.*

(After BARRANDE, Système Silurien, pl. 83, fig. ii, 3A.)

Figs. 34, 35. Brachial and anterior views; showing the asymmetry of the valves, the concentric ornamentation and the perforated deltidium. × 5.

Fig. 36. Cardinal view of a similar specimen. × 4.

Fig. 37. The cardinal process, broken at its tip, probably near the point of bifurcation.

Figs. 38, 39. Interiors of pedicle and brachial valves.

Wenlock limestone. *Dudley, England.*

(After DAVIDSON, British Silurian Brachiopoda, pl. xiii, figs. 15*a*, 17*b*, 16*b*, 21, 19, 20.)

PLATE XII.

(Figures 1-5, 8-21 by R. P. WHITFIELD, 6, 7 by F. B. MEEK.)

Legend. H. Hinge-line.
{D. Deltidium, pedicle-valve.
C. Deltidium, brachial valve.
a. Cardinal area, outer portion.
j. Cardinal process.
i. Lobes of cardinal process.
b. Dental sockets.
t. Teeth.
a. Anterior adductors.
a′. Posterior adductors.
r. Diductors.

GENUS STROPHONELLA, HALL.

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STROPHONELLA (—— ——) STRIATA, Hall.

Fig. 1. The exterior of a brachial valve.

Fig. 2. The interior of a pedicle-valve; showing the extension of the dental lamellæ along the sides of the muscular area, and the crenulations of the cardinal margin near the delthyrium.

Fig. 3. An enlargement of the central portion of the brachial valve; showing the cardinal area, its crenulated margin, and the deltidium enveloping the lower portion of the lobes of the cardinal process. In this drawing the specimen is viewed with the cardinal area nearly at right angles to the line of vision; the groove between the lobes of the cardinal process is, therefore, much foreshortened, and made to appear shallow; the crural ridges are also to be regarded as retreating rapidly into the background.

Niagara group. *Waldron, Indiana.*

STROPHONELLA SEMIFASCIATA, Hall.

Fig. 4. The exterior of the concave pedicle-valve.

Fig. 5. An enlargement of the central portion of the area of both valves; showing the development of the deltidia and the oblique striæ on the broad triangular space enclosed by the lines *a, a, a.* [This space should be defined by lines extending from the apex to the limit of the figure on each side, and which may be obscure in some of the figures.]

Niagara group. *Waldron, Indiana.*

STROPHONELLA LEAVENWORTHANA, Hall.

Fig. 6. The exterior of a brachial valve.

Fig. 7. A profile of the same; showing the concavity in early growth-stages, followed by great convexity and strong geniculation.

Fig. 8. The interior of the brachial valve; showing the crenulations of the cardinal margin, the cardinal process, slightly developed crural plates, and the adductor impressions.

Fig. 9. The interior of the pedicle-valve; showing the crenulations of the hinge-margin, the closed delthyrium, and the arrangement of the muscular scars.

Lower Helderberg group. *Albany county, N. Y.*

STROPHONELLA PUNCTULIFERA, Conrad.

Fig. 10. The exterior of the brachial valve; showing the concavity in the umbonal, and convexity in the pallial region.

Fig. 11. An internal cast of a brachial valve; showing the muscular imprints and the crenulations in the matrix left by the removal of the hinge.

Fig. 12. The cardinal areas of both valves of fig. 10; showing the narrow convex deltidium closing the delthyrium in each valve. $\times 1\frac{1}{2}$.

Lower Helderberg group. *Near Clarksville, N. Y.*

STROPHONELLA AMPLA, Hall.

Fig. 13. An internal cast of a pedicle-valve; showing the muscular impressions and marks of the strongly pustulose interior surface. In the imprint left by the cardinal area are seen the crenulations of the hinge-line, and the mark of the small, linear convex deltidium.

Schoharie grit. *Albany county, N. Y.*

Fig. 14. The interior of a pedicle-valve in which external evidence of the deltidium is lost and the crenulations of the hinge extend more than half the length of the area. The margin of the area on each side of the deltidium has been broken away by the detachment of the cardinal process of the other valve.

Corniferous limestone. *Onondaga Valley, N. Y.*

Fig. 15. An enlargement of the surface striæ.

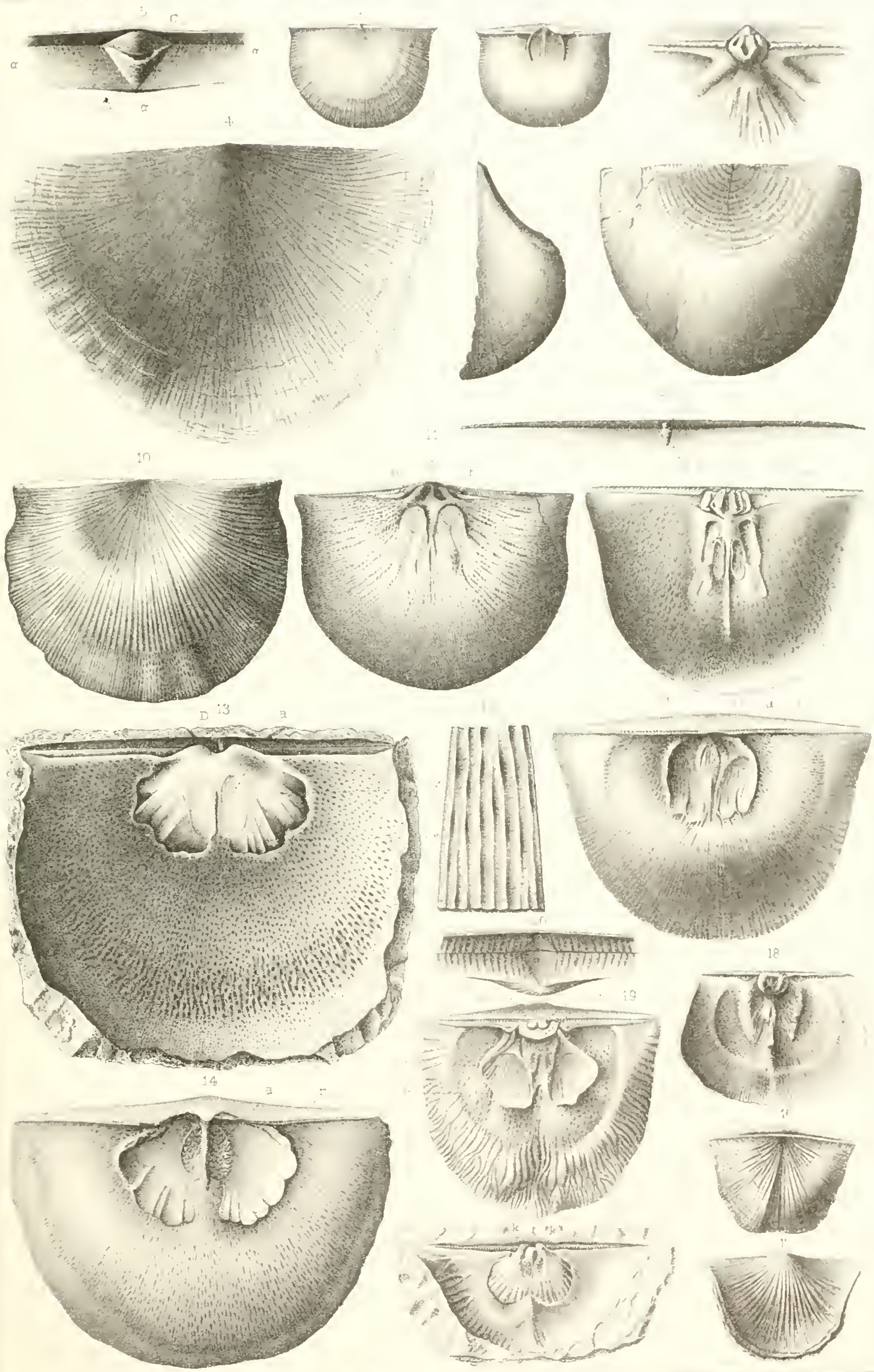

PLATE XII—Continued.

STROPHONELLA REVERSA, Hall.

Fig. 16. View from the brachial valve; showing the uninterrupted area of the pedicle-valve.

Fig. 17. The exterior of the pedicle-valve.

Fig. 18. The interior of a brachial valve; showing the deeply bifurcated cardinal process and the muscular scars.

Fig. 19. The interior of a pedicle-valve in which the muscular and vascular markings are very strong. The cardinal area is seen to be without any trace of deltidium, and the umbonal cavity has been so completely filled by calcareous depositions about the lobes of the cardinal process that the latter have broken and remain attached (*i. i.*) to the pedicle-valve.

Fig. 20. The central portion of the hinge, enlarged, from a specimen which has been somewhat weathered, thus exposing the vertical ridges which terminate in crenulations at the margin, and also showing the limits of the deltidia. × 2.

Upper Devonian. *Rockford, Iowa.*

STROPHONELLA CÆLATA, Hall.

(See Plate XVB, fig 10.)

Fig. 21. A cast of the interior of the pedicle-valve; showing the widely extended, crenulated hinge-line, and the very concave valve with strong muscular and vascular impressions. The points marked *k*, are the filling of the cavities beneath the area for receiving the extremities of the cardinal process.

Chemung group. *Near Elmira, N. Y.*

PLATE XIII.

(Figures 1-27 by R. P. WHITFIELD; 28 by F. B. MEEK, *emend.*)

Legend. H. Hinge-line.
D. Deltidium.
Δ. Delthyrium.
t. Teeth.
b. Dental sockets.
s. Median septum.
j. Cardinal process.
a. Anterior adductors.
a′. Posterior adductors.
r. Anterior diductors.
r′. Posterior diductors.
o. Ovarian spaces.

GENUS STROPHEODONTA, HALL.

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STROPHEODONTA (BRACHYPRION) PROFUNDA, Hall.

(See Plate XX, figs. 29–31.)

Fig. 1. The internal cast of a pedicle-valve; showing the muscular impressions.

Fig. 2. A partial cast of a pedicle-valve with the shell removed from the upper portion; showing the impression of the narrow area. The margin of the valve preserves the shell with its characteristic striæ.

Fig. 3. The central portion of a brachial valve, enlarged from a gutta-percha impression.

Niagara limestone. *Racine, Wisconsin.*

Fig. 4. The interior of a pedicle-valve having the delthyrium but partially closed, and showing the strong crenulations of the cardinal margin near the delthyrium.

Fig. 5. An enlargement of the central portion of the area of the same specimen. × 2.

Niagara group. *Waldron, Indiana.*

STROPHEODONTA (BRACHYPRION) VARISTRIATA, Conrad.

Fig. 6. The exterior of the pedicle-valve.

Fig. 7. The interior of a similar valve.

Fig. 8. An enlargement of a portion of the same specimen; showing the breaking of the area by the detachment of the cardinal process of the opposite valve. × 3.

Fig. 9. An enlargement of the central part of the area of another specimen; showing the character of the deltidium and the short row of crenulations. × 3.

Fig. 10. An enlargement of the umbonal portion of a pedicle-valve; showing the character of the ornamentation. × 3.

Fig. 11. An enlargement of a portion of the interior of the pedicle-valve; showing the crenulations of the hinge and the character of the muscular impressions. × 2.

Fig. 12. The cardinal process and crural plates. × 2.

Figs. 13, 15. Enlargements of the surface striæ.

Fig. 14. The exterior of a pedicle-valve.

Fig. 16. An enlargement of one-half of a small pedicle-valve; showing the fasciculate striæ.

Lower Helderberg group (Tentaculite and Pentamerus limestones). *Schoharie Co., N. Y.*

STROPHEODONTA VARISTRIATA, var. ARATA, Hall.

Figs. 17, 18. Views of two pedicle-valves; showing the strongly fasciculate surface striæ.

Lower Helderberg group. *Becraft's Mountain, Hudson, N. Y.*

STROPHEODONTA PROFUNDA ?

Figs. 19, 20. Views of a specimen which has been referred, with doubt, to this species.

Clinton group. *Niagara county, N. Y.*

STROPHEODONTA VARISTRIATA, Conrad (= *S. impressa*, Conrad).

Figs. 21, 22. Two views of this shell; showing the depressed umbo and the great convexity in the pallial region.

Lower Helderberg group. *Eastern New York.*

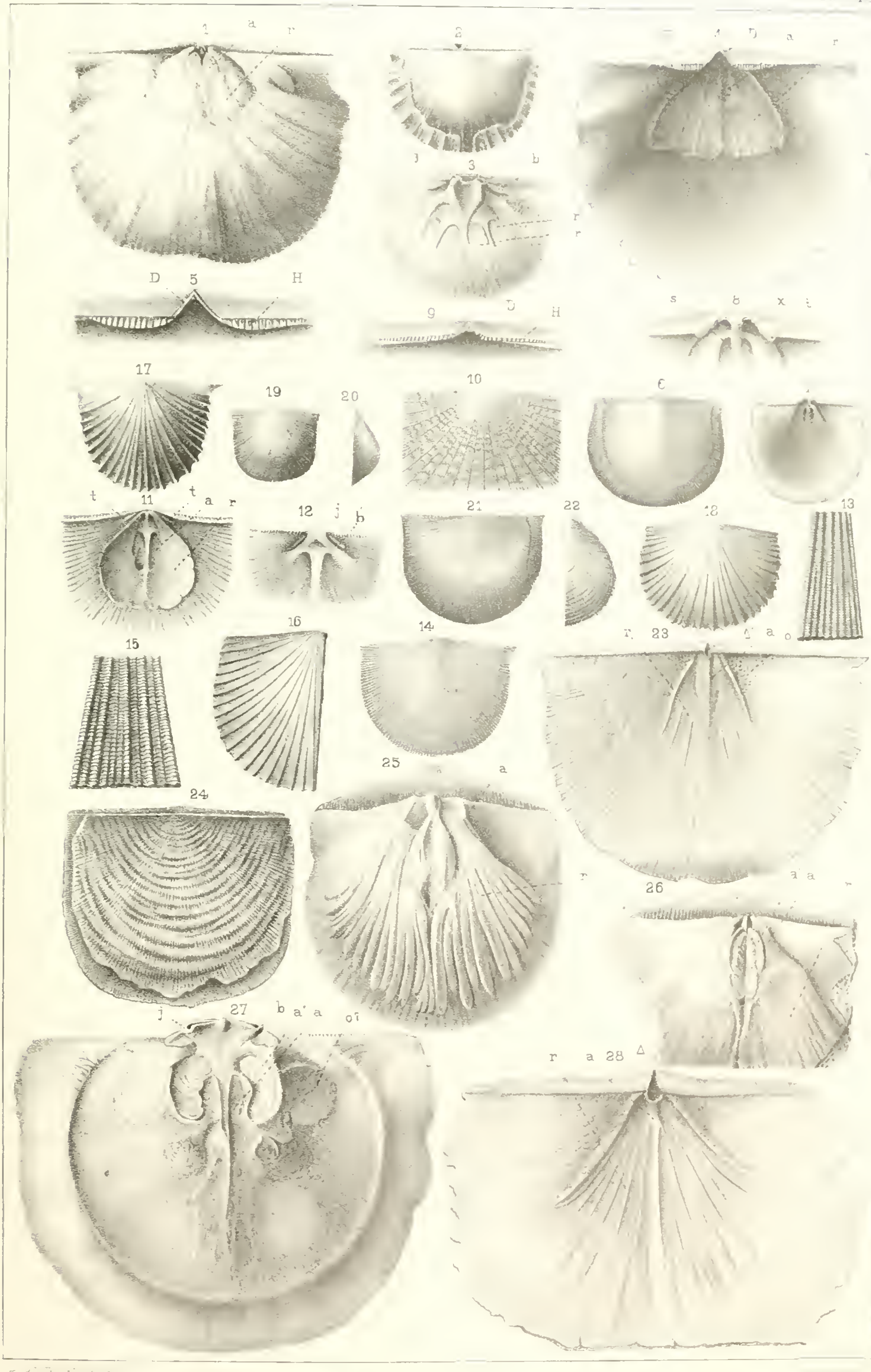

PLATE XIII—Continued.

STROPHEODONTA (LEPTOSTROPHIA) BECKI, Hall.

Fig. 23. The interior of a pedicle-valve. The delthyrium is exposed by the removal of the deltidium, and the short dental lamellæ have united, forming a minute pedicle-pit. The muscular area is bounded laterally by divergent papillose ridges which take their origin at the extremities of the dental lamellæ.

Fig. 24. The exterior of a brachial valve; showing the concentric undulations.

Lower Helderberg group. *Schoharie, N. Y.*

STROPHEODONTA MAGNIVENTRA. Hall

Figs. 25, 26. Natural casts of the interior of pedicle-valves; showing the great development of the muscular areas.

Oriskany sandstone. *Albany county, N. Y.*

STROPHEODONTA (LEPTOSTROPHIA) MAGNIFICA, Hall.

Fig. 27. The interior of a brachial valve, drawn from a gutta-percha impression; showing the character of the cardinal process, which is foreshortened in the figure, the obsolescent dental sockets, the crural plates and the muscular area.

Oriskany sandstone. *Albany county, N. Y.*

Fig. 28. The interior of a pedicle-valve; showing the formation of a pedicle-pit in the delthyrium, by the union of the dental lamellæ; also the expanded, undefined muscular area.

Oriskany sandstone. *Cumberland, Maryland.*

PLATE XIV.

(Figures 1-22 by R. P. WHITFIELD.)

Legend. D. Deltidium.
j. Cardinal process.
s. Septum.
b. Dental sockets.
r, r′. Diductor scars.
a. Anterior adductors.
a′. Posterior adductors.
o. Ovarian spaces.
v. Vascular sinuses.

GENUS STROPHEODONTA, HALL.

Page 284.

STROPHEODONTA (DOUVILLINA) INÆQUISTRIATA, Hall.

Figs. 1, 2, 3. Three views, giving the external characters of the species.

Fig. 4. The interior of a brachial valve.

Fig. 5. The central portion of the interior of the brachial valve, enlarged to show the broad, flat posterior muscular scars and the elevated anterior muscular ridges. × 3.

Fig. 6. The interior of the pedicle-valve, enlarged to show the muscular impressions. × 2.
Hamilton group. *Western New York.*

STROPHEODONTA DEMISSA, Conrad.

Fig. 7. The exterior of a pedicle-valve; showing the fasciculate character of the surface striæ near the beak.

Fig. 8. A view from the brachial valve of a larger individual; showing no evidence of deltidium on the striated cardinal area of the pedicle-valve.

Fig. 9. A profile view of the same.

Fig. 10. An enlargement of the cardinal areas; showing the vertical striæ and complete obsolescence of the deltidia. × $1\frac{1}{2}$.

Fig. 11. The interior of a brachial valve; showing the crenulated hinge-margin, the cardinal process and muscular impressions.

Fig. 12. The interior of a pedicle-valve; showing the muscular impressions. The center of the area has been broken away by the detachment of the cardinal process.
Hamilton group. *Western New York.*

STROPHEODONTA INÆQUIRADIATA, Hall.

Fig. 13. An internal cast of the pedicle-valve; showing the muscular impressions and vascular sinuses.

Fig. 14. An enlargement of the umbonal portion of another cast; showing the dendritic diductor scars, the adductors, and, at *k*, the filling of the cavities occupied by the branches of the cardinal process.
Corniferous limestone. *New York.*

STROPHEODONTA PATERSONI, Hall.

Fig. 15. The exterior of a pedicle-valve; showing, over the visceral region, the undulations of the surface between the primary radii.
Corniferous limestone. *Western New York.*

STROPHEODONTA CONCAVA, Hall.

Figs. 16, 17. Two views, to show the general external character of the shell.

Fig. 18. The umbonal portion of the interior of a brachial valve. From a young individual in which the cardinal process is comparatively slender and the muscular area but slightly thickened. × $1\frac{1}{2}$.
Hamilton group. *York, N. Y.*

Fig. 19. The interior of the brachial valve; showing the characters of the full-grown individual.

Fig. 20. The central cardinal portion of the brachial valve of a mature individual. The lobes of the cardinal process are of great size and deeply grooved, the crural plates in a rudimentary condition and the muscular scars much thickened. × 2

Fig. 21. A posterior view of the same specimen; showing the crenulated edges of the cardinal lobes and the size of the crural plates. At *x* the base of the cardinal process has been excavated for the reception of the margin of the pedicle-valve. × 2.
Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 22. The interior of a pedicle-valve; showing a slight trace of the deltidium.

Fig. 23. An internal cast of the pedicle-valve; showing the adductor and diductor scars.
Hamilton group. *Western New York.*

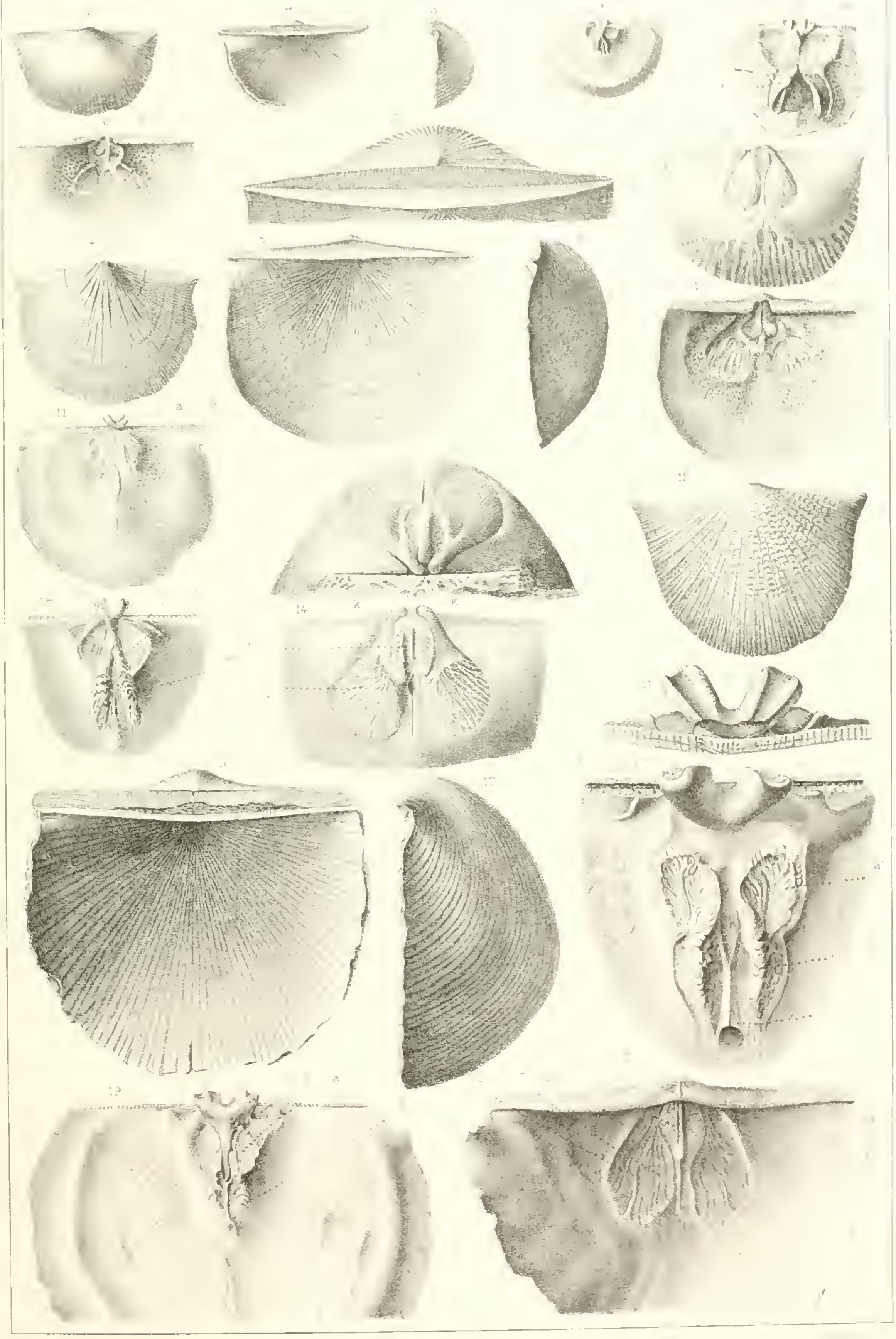

PLATE XV.

(Figures 1–36 by R. P. WHITFIELD.)

Legend.	v. Pedicle-valve.	j. Cardinal process.
	d. Brachial valve.	c. Crura.
	A. Cardinal area.	s. Median septum.
	D. Deltidium.	r. Diductor scars.
	Δ. Delthyrium.	a. Anterior adductors.
	t. Teeth.	a′. Posterior adductors.
	b. Dental sockets.	

GENUS STROPHEODONTA, HALL.

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STROPHEODONTA CORRUGATA, Conrad.

Fig. 1. The exterior of a pedicle-valve; showing the corrugations along the cardinal margin.
Clinton group. *Western New York.*

STROPHEODONTA (LEPTOSTROPHIA) PERPLANA, Conrad.

Fig. 2. View of the brachial valve; showing the cardinal area of the opposite valve.
Corniferous limestone. *Western New York.*

Fig. 3. The pedicle-valve of a smaller specimen.
Hamilton group. *Western New York.*

Fig. 4. The exterior of a pedicle-valve; showing the alternation in size of the striæ.

Fig. 5. An enlargement of the striæ from the same specimen.
Hamilton group. *New Buffalo, Iowa.*

Fig. 6. A similar enlargement where the striæ are of equal size.

Fig. 7. The interior of a pedicle-valve; showing the uninterrupted cardinal area and the thickened pustulose lateral margins of the muscular area.
Hamilton group. *Western New York.*

Fig. 8. The interior of a pedicle-valve retaining similar characters.
Hamilton group. *New Buffalo, Iowa.*

Fig. 9. An enlargement of the interior umbonal portion of the brachial valve; showing the cardinal process and lateral muscular ridges. × 2.
Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 10. The cardinal process, enlarged to show the grooving of the posterior surface of the lobes for the attachment of the diductor muscles. × 3.

Fig. 11. The cardinal areas of both valves; showing the uninterrupted striated surface. × 1½.

Fig. 12. A longitudinal axial section of the two valves; showing the normal curvature of the shell and the position of the cardinal process.

Fig. 13. An enlargement of the surface as left by the removal of the shell.
Hamilton group. *Western New York.*

STROPHEODONTA PERPLANA, Conrad, var. NERVOSA, Hall.

Fig. 14. A portion of a pedicle-valve; showing the irregular character of the striæ.

Fig. 15. An enlargement of a portion of the same.

Fig. 17. A specimen showing the wrinkled striæ and extended cardinal angles.
Chemung group. *Steuben county, N. Y.*

STROPHEODONTA (LEPTOSTROPHIA) JUNIA, Hall.

Fig. 16. A portion of the pedicle-valve; showing the crenulated area and partially covered delthyrium.
Hamilton group. *Canandaigua Lake, N. Y.*

STROPHEODONTA (DOUVILLINA) CAYUTA, Hall.

Fig. 18. An internal cast of the pedicle-valve; showing the short, transverse, sharply defined muscular scar.

Fig. 19. An enlargement of the muscular area of the same specimen. × 2.
Chemung group. *Steuben county, N. Y.*

PLATE XV—Continued.

STROPHEODONTA (PHOLIDOSTROPHIA) NACREA, Hall.

Figs. 20, 21, 22. Three views giving the general external characters of the species.

Fig. 23. The interior of a brachial valve; showing the crenulated hinge-margin, cardinal process and muscular impressions.

Fig. 24. The interior of the pedicle-valve; showing the muscular impressions and partially closed delthyrium.

Hamilton group. *Western New York.*

GENUS PLECTAMBONITES, PANDER.

(See Plate XVA.)

Page 295.

PLECTAMBONITES SERICEA, Sowerby.

Fig. 25. View of the brachial valve; showing the cardinal area and deltidium of the opposite valve.

Fig. 26. The exterior of a pedicle-valve in which the striæ alternate in size.

Fig. 27. The interior of the brachial valve; showing the depressed visceral disk, the muscular scars and cardinal process.

Fig. 28. An enlargement of the cardinal process; showing its union with the crural plates and the abrupt termination of the latter. The process is simple, but on its posterior face appears trilobed from coalescence with the ends of the crural plates. × 3.

Fig. 29. The interior of the pedicle-valve; showing the divergent muscular scars.

Trenton horizon. *Mineral Point, Wisconsin.*

GENUS LEPTÆNISCA, BEECHER.

Page 300.

LEPTÆNISCA CONCAVA, Hall.

Fig. 30. The exterior of a pedicle-valve; showing the scar at the beak, due to the attachment of the shell.

Fig. 31. The interior of the same specimen; showing the deltidium, the strong dental lamellæ and the median septum. × 2.

Lower Helderberg group. *Near Clarksville, N. Y.*

GENUS CHRISTIANIA, GEN. NOV.

Page 298.

CHRISTIANIA SUBQUADRATA, Hall.

Fig. 32. The interior of a brachial valve; showing the bilobed cardinal process and the quadruple adductor scar, divided by high, vertical muscular walls.

Fig. 33. The interior of the pedicle-valve, with an open delthyrium, and showing the muscular walls and scars.

Lower Helderberg horizon. *Perry county, Tennessee.*

GENUS PLECTAMBONITES, PANDER.

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PLECTAMBONITES TRANSVERSALIS, Dalman.

Fig. 34. The exterior of a pedicle-valve. × 2.

Fig. 35. A view from the opposite valve. × 2.

Fig. 36. The interior of a brachial valve; showing the elongate adductor scars. × 2.

Niagara group. *Lockport, N. Y.*

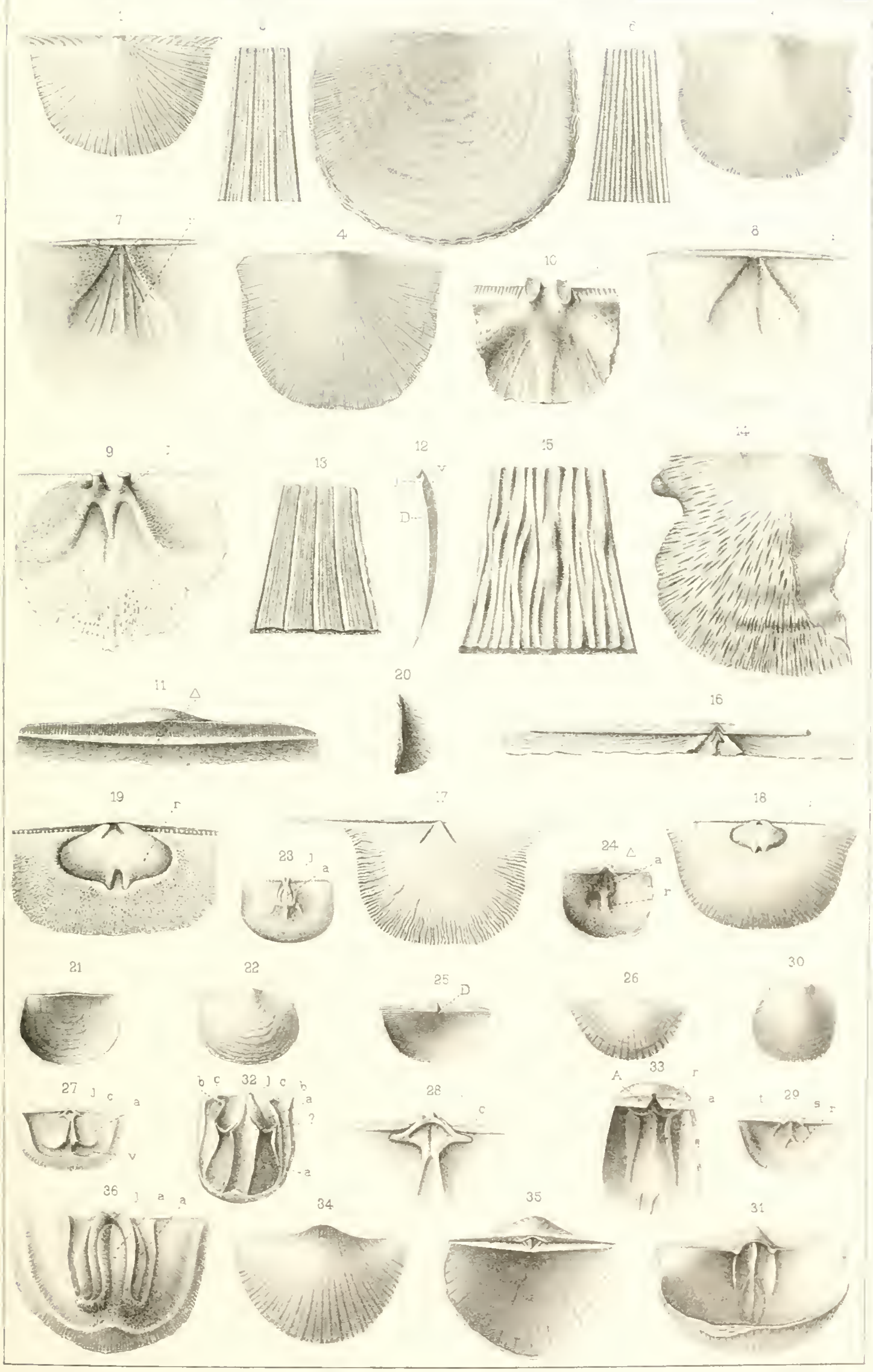
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PLATE XV A.

(Figures 1-18, 20-22, 24-28, 39, 40, 43 by E. EMMONS; 19, 23, 34, 35, 37, 38 by G. B. SIMPSON; 29, 30 by J. M. CLARKE; 41, 42 by C. E. BEECHER; 31-33 copies.)

Legend. D. Deltidium (pedicle-valve).
C. Deltidium (brachial valve).
ps. Pedicle-sheath.
F. Foramen
t. Teeth.
d. Dental lamellæ.
l. Spondylium.
j. Cardinal process.
c. Crura.
br. Brachial ridges.
a. Anterior adductor scars.
a′. Posterior adductor scars.
r. Diductor scars.
x. Scar of attachment.

GENUS CLITAMBONITES, PANDER.

(See Plate VII.)
Page 233.

CLITAMBONITES VERNEUILI, (von Eichwald) Billings (= *Hemipronites Americanus*, Whitfield).

Figs. 1, 2. Opposite sides of conjoined valves. Figure 2 shows that the deltidium has been lost, exposing the spondylium.

Fig. 3. The interior of a pedicle-valve which does not retain the deltidium; showing the concave delthyrial plate or spondylium supported by a median septum.

Fig. 4. A view of the same specimen, looking into the umbonal cavity of the valve.

Trenton horizon. *Cannon Falls, Minnesota.*

Figs. 5, 6. Interiors of brachial valves; showing the simple cardinal process abutting against the deltidium, and the quadripartite impression of the adductor muscles.

Trenton horizon. *Island of Anticosti.*

Figs. 7, 8. Profile and cardinal views of a small pyramidal specimen which may be a variety of this species. The deltidia of both valves are retained, that of the pedicle-valve being perforated by a large foramen.

Trenton horizon. *Cannon Falls, Minnesota.*

GENUS HIPPARIONYX, VANUXEM.

(See Plate IX.)
Page 257.

HIPPARIONYX PROXIMUS, Vanuxem.

Fig. 9. The interior of a pedicle-valve drawn from a gutta-percha impression of a natural mould; showing the character of the cardinal area and dental lamellæ, the great size of diductor scars, the margins of which are thickened and elevated by the deposition of testaceous matter. The surface of the elevations thus formed is strongly pitted. The specimen also shows the low median septum dividing the adductor impression, which in the umbonal region unites with the dental lamellæ to form an apical callosity.

Fig. 10. The cardinal process and crural plates of the brachial valve. The crenulations of the margin of the valve are seen to extend almost to the base of the process.

Oriskany sandstone. *Albany county, N. Y.*

Fig. 11. Profile of an internal cast of the two valves. The specimen is drawn with the brachial valve above and shows the relative convexity of the valves and the extent of the crenulated margin toward the apices.

Oriskany sandstone. *Cayuga, Province of Ontario.*

For further illustration, see Palæontology of New York, Volume III, plates 89, 90.

GENUS LEPTELLA, GEN. NOV.

Page 293.

LEPTELLA SORDIDA, Billings (sp.).

Figs. 12, 13. Two views of a specimen retaining both valves, and showing the outline, contour and general external characters of the species. The delthyrium of the pedicle-valve is partially closed by a convex deltidium. × 3.

Fig. 14. The interior of a pedicle-valve; showing the cardinal area, deltidium and teeth, but no trace of the muscular scars is retained. × 3.

Fig. 15. The interior of a brachial valve. The cardinal process consists of two independent apophyses, not coalesced with the crural plates, the latter being depressed at their origin but considerably elevated at their extremities. The visceral region is concave on either side of a broad median ridge and its surface radially striated; from its anterior margin the surface of the valve is abruptly and evenly deflected. × 5.

Fig. 16. Cardinal view of the same specimen; showing the width of the area, the posterior face of the cardinal process and the elevation of the crural plates. × 5.

These figures are from the original specimens of the species.

"*Point Lévis; in the upper part of the Limestone No. 2, Quebec group.*" (BILLINGS.)

GENUS ANOPLIA, GEN. NOV.

(See Plate XX.)

Page 309.

ANOPLIA NUCLEATA, Hall.

Fig. 17. Cardinal view of an internal cast of the pedicle-valve, retaining the impressions of the extremely oblique dental lamellæ and the short median septum; also showing the indistinct outline of the muscular area. × 3.

Fig. 18. The interior of the brachial valve which has a close similarity to that of CHONETES. × 2.

Oriskany sandstone. *Albany county, N. Y.*

See also the illustrations in Palæontology of New York, Volume III, plate 91, figs. 1 *a–d*.

GENUS LEPTÆNISCA, BEECHER.

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LEPTÆNISCA CONCAVA, Hall.

(See Plate XV, figs. 30, 31.)

Fig. 19. The exterior of a pedicle-valve; showing the contour and character of the surface. × 2.

Fig. 20. The interior of a brachial valve, somewhat imperfect about the margins and cardinal process, but showing the spiral brachial ridges and the thin median septum. × 2.

Fig. 21. Cardinal view of an imperfect brachial valve preserving the character of the cardinal process, which is deeply quadrilobate. × 3.

Figures 20 and 21 are from specimens illustrated by Mr. BEECHER.

Lower Helderberg group. *Near Clarksville, N. Y.*

LEPTÆNISCA ADNASCENS, sp. nov.

Fig. 22. A pedicle-valve attached by nearly its entire outer surface to the interior of a valve of *Orthis oblata*. The specimen shows the dental lamellæ and median ridge dividing the muscular area. × 3.

Fig. 23. A specimen retaining both valves, attached to *Orthis perelegans*. × 4.

Lower Helderberg group. *Near Clarksville, N. Y.*

LEPTÆNISCA TANGENS, sp. nov.

Fig. 24. The exterior of a pedicle-valve with the umbo flattened from attachment, and showing the low median sinus. × 2.

Fig. 25. The interior of the same specimen; showing the cicatrix of attachment (x), the deltidium and the dental lamellæ × 2.

Fig. 26. The exterior of a pedicle-valve in which the rugose growth has obscured the median sinus. The deep umbonal depression has been caused by attachment to some bryozoan. × 3.

Figs. 27, 28. Opposite sides of a pedicle-valve attached to a twig of TREMATOPORA. × 3.

Figs. 29, 30. Opposite sides of a similar valve which has been attached to a frond of FENESTELLA. × 3.

These last two specimens show the bilobate exterior, the deltidium, teeth, strong dental lamellæ produced about the muscular area, and the short median septum.

Lower Helderberg group. *Near Clarksville, N. Y.*

BRACHIOPODA

Generic Illustrations

Plate XV A

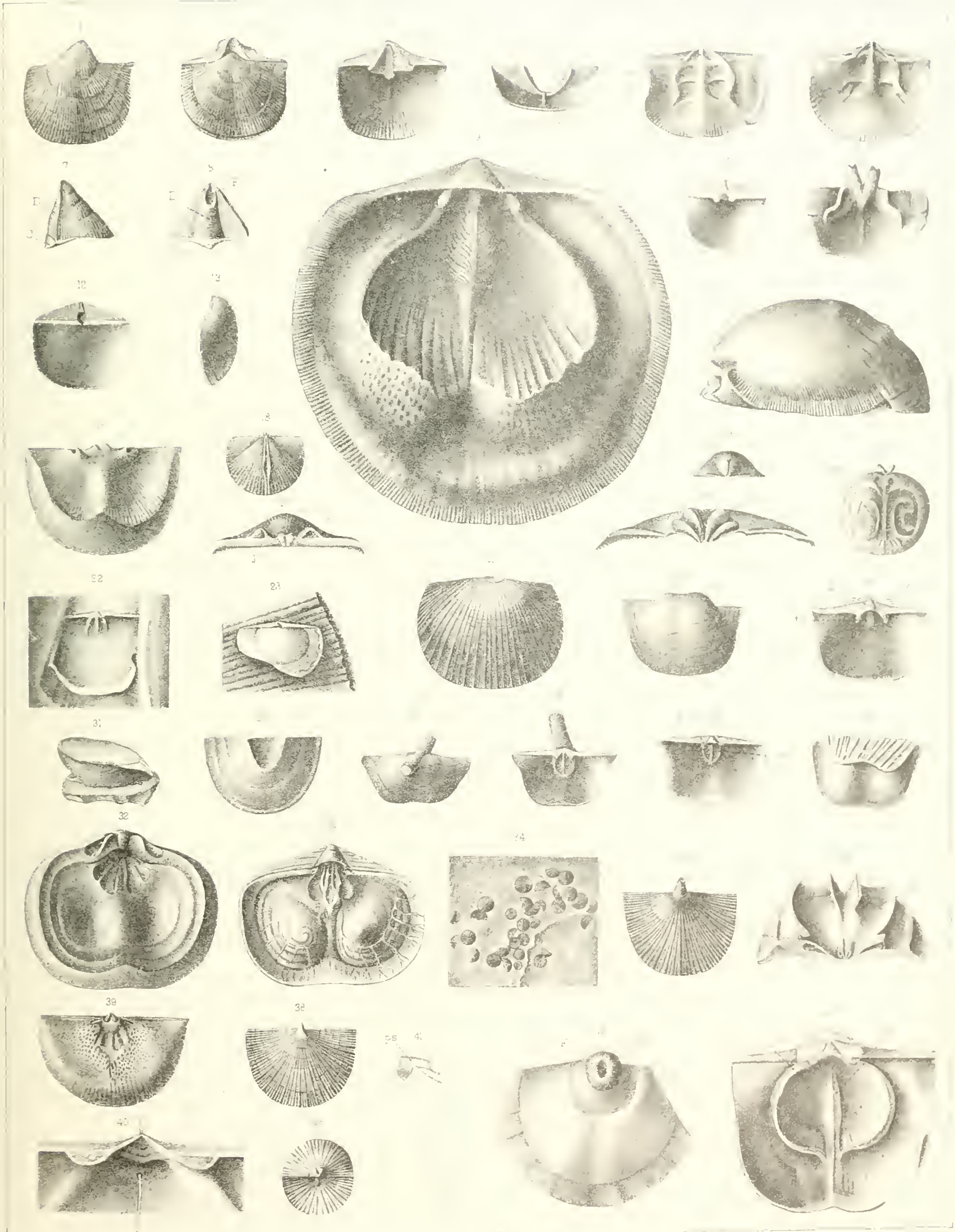

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PLATE XVA—Continued.

Genus DAVIDSONIA, Bouchard.

Page 301.

Davidsonia Verneuiliana, Bouchard.

Fig. 31. Profile of an attached specimen retaining the two valves.

Figs. 32, 33. Interiors of the brachial and pedicle-valves respectively. After Davidson.

Genus PLECTAMBONITES, Pander.

(See Plate XV.)

Page 295.

Plectambonites plicatella, Ulrich.

Fig. 34. A group of these shells which have fallen into the sediment with their valves attached and open.

Fig. 35. One of the shells, enlarged. The surface exposed is the exterior, the concave or brachial valve showing, from compression, the outline of the cardinal process. × 5.

Hudson River group. *Covington, Kentucky.*

Genus CHRISTIANIA, gen. nov.

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Christiania subquadrata, Hall.

(See Plate XV, figs. 32, 33.)

Fig. 36. Cardinal view of the brachial valve; showing the bilobed cardinal process, widely divergent crural plates, the prominent longitudinal and transverse muscular ridges enclosing the impression of the adductor muscles. × 3.

Lower Helderberg group. *Perry county, Tennessee.*

Genus RAFINESQUINA, gen. nov.

(See Plate VIII.)

Page 281.

Rafinesquina Ulrichi, James.

Figs. 37, 38. The exterior of two mature pedicle-valves in which the primitive condition of the pedicle-passage as a tube or sheath is retained. This appears to be a normal feature of maturity in this species. × 2.

Hudson River group. *Covington, Kentucky.*

Rafinesquina unicostata, Meek and Worthen.

Fig. 39. The interior of a brachial valve; showing the cardinal process, dental sockets and muscular area.

Hudson River group. *Spring Valley, Minnesota.*

Genus LEPTÆNA, Dalman.

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Leptæna rhomboidalis, Wilckens.

(See Plate VIII, figs. 17–31; Plate XX, figs. 21–25.)

Fig. 40. The central cardinal portion of a mature pedicle-valve; showing the position of the inner opening of the foramen. A bristle has been drawn through the foramen to show that the passage was open at maturity. × 3.

Lower Helderberg group. *Near Clarksville, N. Y.*

Figs. 41, 42. Two views of the youngest specimen obtained; much enlarged to show the structure of the pedicle-passage in its earliest observed condition. × 10. After Beecher and Clarke.

Niagara group. *Waldron, Indiana.*

Leptæna rhomboidalis, var. ventricosa, Hall.

Fig. 43. The interior of a pedicle-valve; showing the great prominence of the muscular ridges about the diductor scars and the thickened central adductor impression.

Oriskany sandstone. *Cumberland, Maryland.*

PLATE XVb.

(Figures 1-9, 14-19, 21, 22, 28-30, 32-35 by G. B. Simpson; 10-13, 24-26, 36, 37 by R. P. Whitfield; 20, 23, 27, 31 by E. Emmons.)

Legend. j. Cardinal process. r. Diductor scars.
a. Adductor scars.

Genus STROPHEODONTA, Hall.

(See Plates XIII, XIV, XV, XX.)
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Stropheodonta (Douvillina) arcuata, Hall.

Fig. 1. The interior of a pedicle-valve; showing the cavity in the cardinal area as left by the removal of the cardinal process, the thickened, sharply defined and elevated muscular area.

Fig. 2. The interior of the brachial valve.

Fig. 3. The same enlarged, to show the character of the cardinal process, the small crural plates and divergent muscular ridges. × 2.

Upper Devonian, *Lime Creek, Iowa.*

Stropheodonta variabilis, Calvin.

Figs. 4, 5. Opposite sides of the same specimen; showing the contour and surface ornamentation. × 2.

Fig. 6. The interior of the brachial valve; showing the cardinal process and divergent muscular ridges. × 2.

Upper Devonian. *Lime Creek, Iowa.*

Stropheodonta (Douvillina) Cayuta, Hall.

Fig. 7. The interior of a pedicle-valve; showing the sharply defined, thickened and elevated muscular area and its subdivisions.

Fig. 8. The interior of a brachial valve; showing the muscular ridges.

Chemung group. *Tioga county, Pennsylvania.*

Stropheodonta (Douvillina?) inæquistriata, Hall.

Fig. 9. The interior of a pedicle-valve; showing the greatly thickened lateral margins of the muscular impression

Hamilton group. *Canandaigua Lake, N. Y.*

Genus STROPHONELLA, Hall.

(See Plate XII.)
Page 290.

Strophonella cælata, Hall.

Fig. 10. The interior of a brachial valve in an unusually fine state of preservation. The flabellate muscular scars have the form usual to this genus and similar to that characterizing Douvillina. The crenulations of the hinge-line do not extend to the extremities of the cardinal area; a feature of frequent occurrence in many of the earlier species of Stropheodonta. The impressions of the pallial sinuses are also distinctly shown.

Chemung group. *Near Addison, N. Y.*

Genus CHONETES, Fischer de Waldheim.

(See Plate XVI.)
Page 303.

Chonetes Flemingi, Norwood and Pratten.

Fig. 11. The interior of a pedicle-valve; showing the character of the muscular scars and the internal openings of the spine-tubes beneath the cardinal area. × 3.

Coal Measures. *Illinois.*

Chonetes Smithi, Norwood and Pratten.

Fig. 12. The interior of a brachial valve; showing the four scars of the adductor muscles. × 2.

Coal Measures. *Illinois.*

CHONETES AMAZONICA, Derby.

Fig. 13. An enlargement of an internal cast of the pedicle-valve, which retains the filling of the spine-tubes crossing the cavity left by the removal of the cardinal portion of the valve. × 3.

Coal Measures. *Rio Tapajos, Brazil.*

GENUS CHONOSTROPHIA, GEN. NOV.

(See Plate XVI.)

Page 310.

CHONOSTROPHIA HELDERBERGIA, sp. nov.

Fig. 14. A specimen in which the valves are opened, exposing their internal surfaces. The shell may have been somewhat flattened in fossilization, but still shows the reversal of the relative convexity of the valves, the cardinal area, teeth and faint median septum of the pedicle-valve and the finely lineate surface. The cardinal process is not retained with sufficient distinctness to permit its accurate delineation.

Lower Helderberg group. *Near Clarksville, N. Y.*

CHONOSTROPHIA REVERSA, Whitfield.

Fig. 15. The exterior of a pedicle-valve; showing its gentle concavity and fasciculate ornamentation. × 2.

Corniferous limestone. *Delaware, Ohio.*

Fig. 16. The exterior of a pedicle-valve which retains the cardinal spines. × 2.

Fig. 17. The interior of a brachial valve; showing the contour of the shell and retaining the cardinal process. × 2.

Upper Helderberg group. *Cayuga, Ontario.*

Fig. 18. An enlargement of the cardinal process and crural plates. The former is bilobed but short, and terminates abruptly at the base. The crural plates are also quite short and have a slightly sinuous curvature. × 6.

Fig. 19. An enlargement of the surface striæ; showing their fasciculate grouping. × 6.

Corniferous limestone. *Delaware, Ohio.*

GENUS CHONOPECTUS, GEN. NOV.

(See Plate XVI.)

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CHONOPECTUS FISCHERI, Norwood and Pratten.

Fig. 20. The exterior of a pedicle-valve which retains the reticulate surface ornamentation and a large scar of attachment. × 2.

In strata referred to the age of the Waverly group. *Warren, Pennsylvania.*

Fig. 21. A pedicle-valve having the normal proportions of the species, and showing a few spine-bases on the cardinal margin. The reticulate surface markings, as on this specimen, do not usually extend over the pallial region, which is covered by exceedingly fine, often irregular radiating striæ.

Fig. 22. Posterior view of the umbonal region in the same specimen, enlarged to show character of the cicatrix. × 2.

Fig. 23. A small pedicle-valve, retaining the cardinal spines and showing, over the body of the shell, some divergent impressions which may be of vascular origin.

Yellow sandstones. *Burlington, Iowa.*

GENUS STROPHALOSIA, King.

(See Plates XVI, XVII, XVIIA.)

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STROPHALOSIA TRUNCATA, Hall.

Fig. 24. An internal cast of a pedicle-valve; showing the muscular impressions; enlarged.

Fig. 25. The interior of a pedicle-valve; enlarged.

Fig. 26. The exterior of a pedicle-valve; showing the spiniferous surface; enlarged.

Marcellus shales. *New York.*

STROPHALOSIA RADICANS, Winchell.

Fig. 27. A pedicle-valve, attached by its entire outer surface and spines to a FISTULIPORA. × 2.

Fig. 28. A pedicle-valve, situated in a cavity among the polypites of *Acervularia Davidsoni*. There is a slight attachment by the apex of the valve, but fixation is mainly effected by the spines, those on the cardinal margin creeping along the surface of a polypite, and several of those which are on the body of the valve crossing the cavity, their extremities being somewhat obscured by the matrix of the specimen. These latter spines appear to increase slightly in diameter from the surface of the shell outward, and their surface is marked with fine concentric annulations. × 3.

Fig. 29. The calyx of a single polypite of *Acervularia Davidsoni*, to which is attached a pedicle-valve of this species; its adherent spines running between the septa of the coral. × 3.

Fig. 30. An attached specimen, which retains the concave brachial valve in position, and shows the cardinal areas and deltidia of both valves. × 3.

Hamilton group. *Little Traverse Bay, Michigan.*

STROPHALOSIA HYSTRICULA, Hall.

(See Plate XVII, figs. 29, 30.)

Fig. 31. An internal cast of a pedicle-valve, which shows the scar of attachment and impressions of the bases of spines over the body of the shell. × 3.

Chemung group. *Conewango, N. Y.*

STROPHALOSIA SCINTILLA, Beecher.

Fig. 32. A specimen retaining both valves, attached to the surface of *Spirifer Marionensis*. This specimen shows no trace of spines. × 6.

Fig. 33. Another specimen which retains both valves, attached to a brachial valve of *Productella pyxidata*. The spines about the margin should have been represented as belonging to the lower, not to the upper (brachial) valve. × 6.

Fig. 34. The interior of a pedicle-valve attached to the surface of *Syringothyris Hannibalensis*; showing the few short spines which characterize the species. × 4.

Choteau limestone. *Pike county, Missouri.*

STROPHALOSIA, sp. ?

Fig. 35. A very small specimen attached to *Spirifer Marionensis*. This specimen is peculiar in showing spines on the surface of the brachial valve. It occurs in association with *S. scintilla*, and it may possibly prove the young of that species. × 8.

STROPHALOSIA CORNELLIANA, Derby.

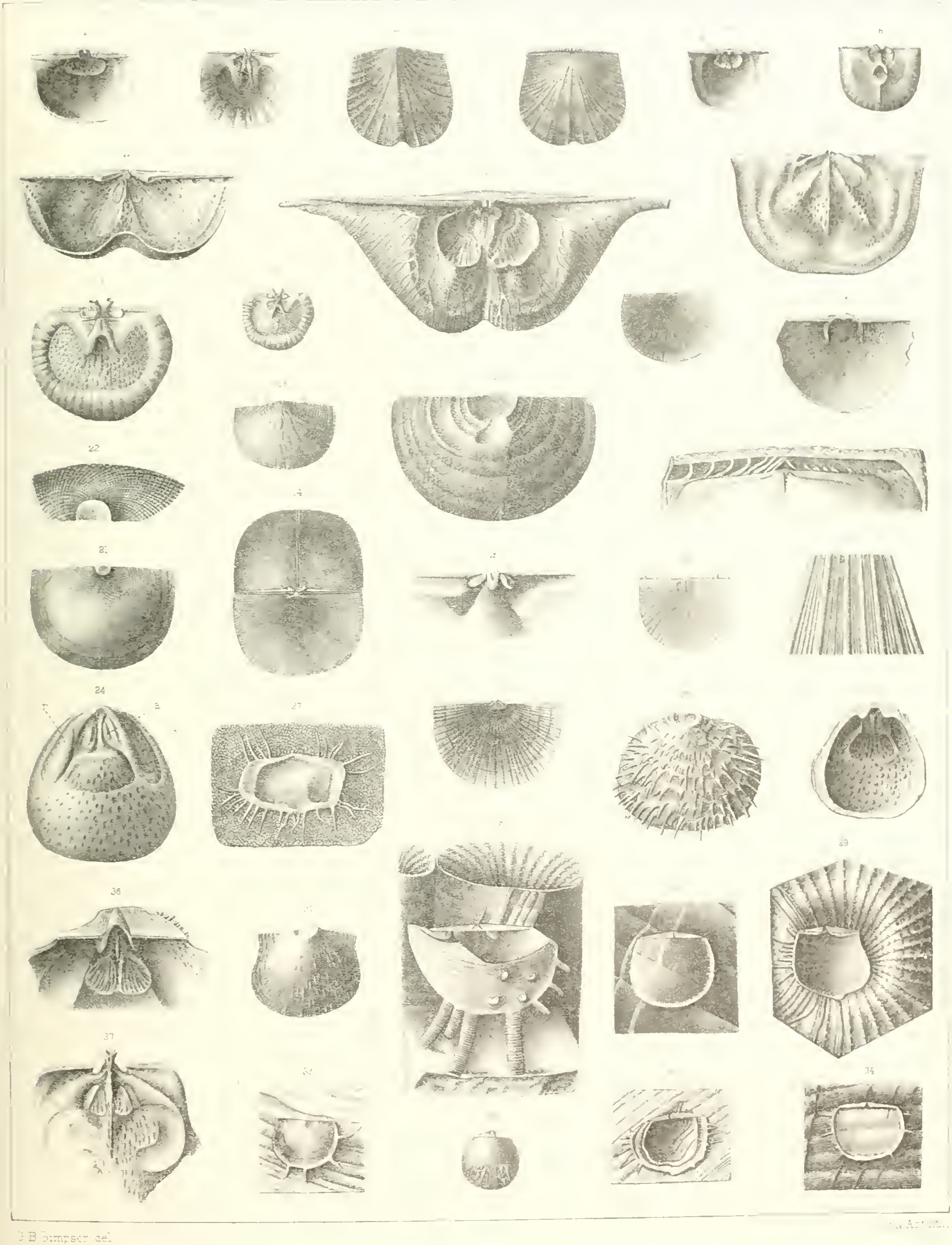
Fig. 36. Posterior portion of the interior of the pedicle-valve; showing the area, deltidium, teeth and muscular scars. × 3.

Fig. 37. The interior of an imperfect brachial valve which retains the cardinal process, and shows the muscular scars and brachial impressions. × 3.

Coal Measures. *Bomjardim, Brazil.*

BRACHIOPODA.

Strophomenidae and Productidae.



G. B. Simpson del.

PLATE XVI.

(Figures 1-16, 18-22, 24-30, 32-44 by R. P. Whitfield; 17, 31 by F. B. Meek; 23 copy.)

Legend. D. Deltidium, pedicle-valve.
C. Deltidium, brachial valve.
st. Cardinal tubes.
t. Teeth.
b. Dental sockets.
s. Septum.
j. Cardinal process.
a. Anterior adductors.
a′. Posterior adductors.
r. Anterior diductors.
r′. Posterior diductors.
v. Brachial ridges.

Genus CHONETES. Fischer de Waldheim.

(See Plate XVb.)
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Chonetes cornuta, Hall.

Fig. 1. A view of the pedicle-valve. × 2.
Clinton group. *Sodus Bay, N. Y.*

Chonetes setigera, Hall.

Fig. 2. A view of the pedicle-valve. × 2.
Waverly group. *Penfield, Ohio.*

Fig. 5. Pedicle-valve of a larger specimen with finer striæ. × 2.

Fig. 19. An enlargement of the surface striæ of this specimen.
Marcellus shales. *Near Caledonia, N. Y.*

Chonetes scitula, Hall.

(?)Fig. 3. A pedicle-valve, with somewhat more circular outline and longer cardinal spines than usual. × 2.

Fig. 4. A view of the brachial valve; showing the cardinal area and deltidium.

Fig. 27. The interior of a brachial valve; showing the structure of the cardinal process and the faint brachial ridges. × 2.

Fig. 32. The interior of the pedicle-valve; showing the cardinal area and teeth. × 2.
Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 40. An enlargement of the cardinal portion of the valves; showing the hollow spines and the curving course of the spine-tubes through the substance of the cardinal area of the pedicle-valve. × 8.
Hamilton group. *Western New York.*

Fig. 44. An internal cast of the pedicle-valve, retaining the filling of the spine-tubes and showing their convergence toward the beak before reaching the upper margin of the area. × 8.
Chemung group. *Cattaraugus county, N. Y.*

Chonetes mucronata, Hall.

Fig. 6. A pedicle-valve with very coarse plications and apparently destitute of spines. × 2.

Fig. 7. A pedicle-valve with long, extremely divergent spines. × 2.
Marcellus shales. *West Avon, N. Y.*

Chonetes acutiradiata, Hall.

Fig. 8. The pedicle-valve.
Corniferous limestone. *Williamsville, N. Y.*

Chonetes Logani, Norwood and Pratten, var. Aurora, Hall.

Fig. 9. Pedicle-valve, enlarged to show the fine concentric striæ. × 3.

Fig. 18. An enlargement of the surface.
Tully limestone. *Tully, N. Y.*

CHONETES CORONATA, Conrad.

Fig. 10. A view of the brachial valve; showing the cardinal area and deltidium.

Fig. 11. A pedicle-valve with unusually strong concentric growth-lines.

Hamilton group. *Darien, N. Y.*

Fig. 24. The interior of a brachial valve; showing the cardinal process, muscular scars and brachial ridges.

Hamilton group. *York, N. Y.*

Fig. 26. The interior of another brachial valve; showing more distinctly the quadripartite character of the cardinal process.

Fig. 33. The interior of a pedicle-valve; showing the cardinal area, teeth and muscular scars.

Hamilton group. *Western New York.*

GENUS STROPHALOSIA, KING.

(See Plates XVB, XVII, XVIIA.)

Page 314.

STROPHALOSIA MURICATA, Hall.

Fig. 12. The exterior of the pedicle-valve, from a gutta-percha impression of a natural mould; showing the short spines on the surface.

Fig. 16. Two views of a pedicle-valve; showing the cicatrix of attachment.

Fig. 30. The interior of a brachial valve, from a gutta-percha impression; showing the cardinal process, brachial ridges and median septum.

Fig. 38. An internal cast of the pedicle-valve; showing the muscular impressions.

Fig. 42. An enlargement of the muscular scars restored from several internal casts of the pedicle-valve.

Chemung group. *Meadville, Pennsylvania.*

GENUS CHONOSTROPHIA, GEN. NOV.

(See Plate XVB.)

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CHONOSTROPHIA COMPLANATA, Hall.

Fig. 13. The interior of the pedicle-valve from a gutta-percha impression; showing the reversed convexity of the shell, the flabellate muscular area, conspicuous median septum, and the cardinal spines.

Fig. 29. Another interior of a similar valve in which the cardinal spines are apparently absent.

Oriskany sandstone. *Albany county, N. Y.*

GENUS CHONETES, FISCHER DE WALDHEIM.

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CHONETES HEMISPHÆRICA, Hall.

Fig. 14. A view of the pedicle-valve; showing its great convexity.

Schoharie grit. *Albany county, N. Y.*

CHONETES ARCUATA, Hall.

Fig. 15. Profile of a pedicle-valve, from which the radiating striæ have been accidentally omitted in lithographing.

Figs. 35, 36. Two views of an internal cast of the pedicle-valve; showing the muscular impressions and the crenulation of the cardinal area, caused by the casts of the spine-tubes.

Corniferous limestone. *Near Williamsville, N. Y.*

GENUS CHONOPECTUS, GEN. NOV.

(See Plate XVB.)

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CHONOPECTUS FISCHERI, Norwood and Pratten.

Fig. 17. The exterior of a pedicle-valve; showing the concentrically reticulate surface.

Fig. 31. An enlargement of the surface; showing the double series of concentric wrinkles crossing the fine radiating striæ.

Yellow sandstones. *Burlington, Iowa.*

BRACHIOPODA

Palæont. N.Y. Vol IV. Pt II

Generic Illustrations

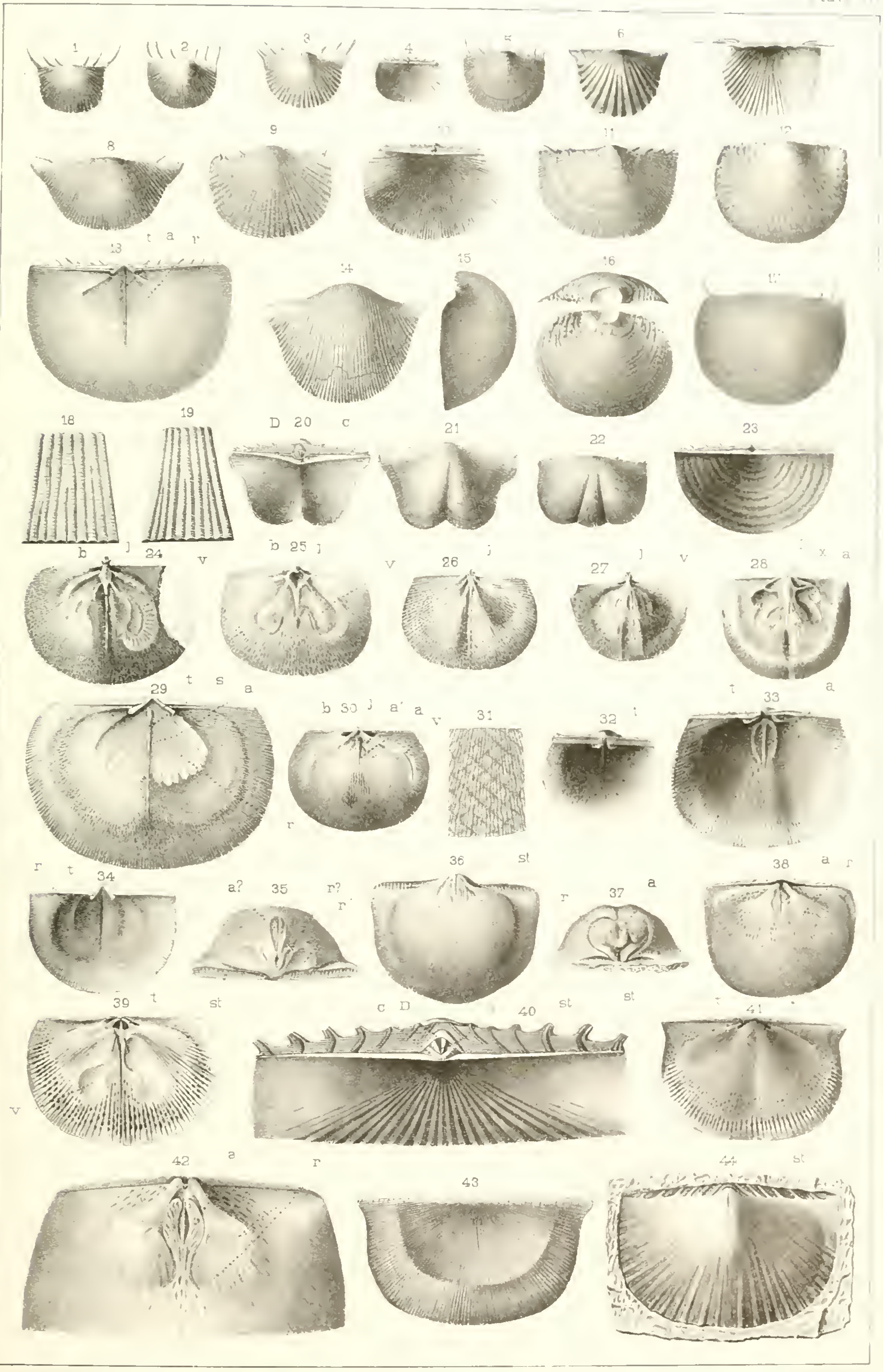

PLATE XVI—Continued.

GENUS CHONETES, FISCHER DE WALDHEIM.

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CHONETES VERNEUILIANA, Norwood and Pratten.

Figs. 20, 21. Two views; showing the strong median constriction. × 2.
Coal Measures. *Illinois.*

CHONETES MESOLOBA, Norwood and Pratten.

Fig. 22. A pedicle-valve; showing the median fold. × 2.
Coal Measures. *Illinois.*

CHONETES CONCENTRICA, de Koninck.

Fig. 23. A species in which the surface is covered with strong concentric wrinkles. This species may not prove congeneric with *Chonetes striatella,* Dalman.
Lower Carboniferous limestone. *Visé, Belgium.*

CHONETES LOGANI, Norwood and Pratten.

Fig. 25. The interior of a brachial valve; showing the brachial ridges. Drawn from a gutta-percha impression. × 2.
Waverly group. *Wayne county, Ohio.*
See Part ii, Volume VIII, for further illustration.

CHONETES DEFLECTA, Hall.

Fig. 28. The interior of a brachial valve. × 2.
Hamilton group. *Western New York.*

CHONETES LINEATA, Conrad.

Fig. 34. The interior of a pedicle-valve; showing the area, teeth and muscular impressions. × 2.
Corniferous limestone. *Western New York.*

CHONETES SYRTALIS, Conrad (= *C. coronata,* Conrad).

Fig. 39. An internal cast of the brachial valve; showing the brachial ridges.
Fig. 41. An internal cast of the pedicle-valve.
Fig. 43. An impression of the exterior of a large shell.
Hamilton group. *Eastern New York.*

GENUS STROPHEODONTA, HALL.

(See Plates XIII, XIV, XV, XVB, XX.)

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STROPHEODONTA CALLOSA, Hall.

Fig. 37. An enlarged cardinal view of the pedicle-valve; showing the muscular impressions and crenulations of the area.
Schoharie grit. *Near Clarksville, N. Y.*

PLATE XVII.

(Figures 1-15, 18-29, 33-46 by R. P. WHITFIELD; 16, 31, 32 by F. B. MEEK; 47-51 copies.)

Legend. A. Cardinal area.
D. Deltidium, pedicle-valve.
C. Deltidium, brachial valve.
t. Teeth.
b. Dental sockets.
j. Cardinal process.
v. Brachial ridges.
a. Anterior adductors.
a'. Posterior adductors.
r. Diductors.

GENUS PRODUCTELLA, HALL.

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PRODUCTELLA SUBACULEATA, (Murchison) Hall.

Fig. 1. The exterior of a pedicle-valve.
Corniferous limestone. *Falls of the Ohio.*

Fig. 2. The interior of a brachial valve; showing the cardinal process.
Corniferous limestone. *East Victor, N. Y.*

PRODUCTELLA SPINULICOSTA, Hall.

Figs. 3, 5. Two views of a pedicle-valve.
Corniferous limestone. *Louisville, Kentucky.*

Fig. 4. The exterior of a pedicle-valve.
Marcellus shales. *Western New York.*

Fig. 6. A pedicle-valve referred with doubt to this species.
Yellow sandstones. *Burlington, Iowa.*

PRODUCTELLA SHUMARDIANA, Hall.

Fig. 7. A pedicle-valve with distinct spiniferous costæ. This figure is from one of the original specimens of the species.
Yellow sandstones. *Burlington, Iowa.*

PRODUCTELLA NAVICELLA, Hall.

Figs. 8, 9. Views of the interior and exterior of the pedicle-valve.
Hamilton group. *Western New York.*

GENUS STROPHALOSIA, KING.

(See Plates XVB, XVI.)

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STROPHALOSIA TRUNCATA, Hall.

(See Plate XVB, figs. 24-26.)

Fig. 10. The interior of a brachial valve; showing the cardinal process.

Fig. 11. The exterior of a brachial valve; showing the convex umbo corresponding to the truncation of the apex of the opposite valve. × 2.

Figs. 12, 13. Two views of a pedicle-valve; showing the truncation of the beak. × 2.
Marcellus shales. *Western New York.*

Fig. 14. An impression of the external surface of the brachial and part of the pedicle-valve; showing the cardinal areas and minute deltidia. × 2.
Hamilton group. *Near Tully, N. Y.*

Fig. 15. An enlargement of the cardinal process; showing its simple, uncoalesced lobes. × 6.
Marcellus shales. *Western New York.*

GENUS PRODUCTELLA, HALL.

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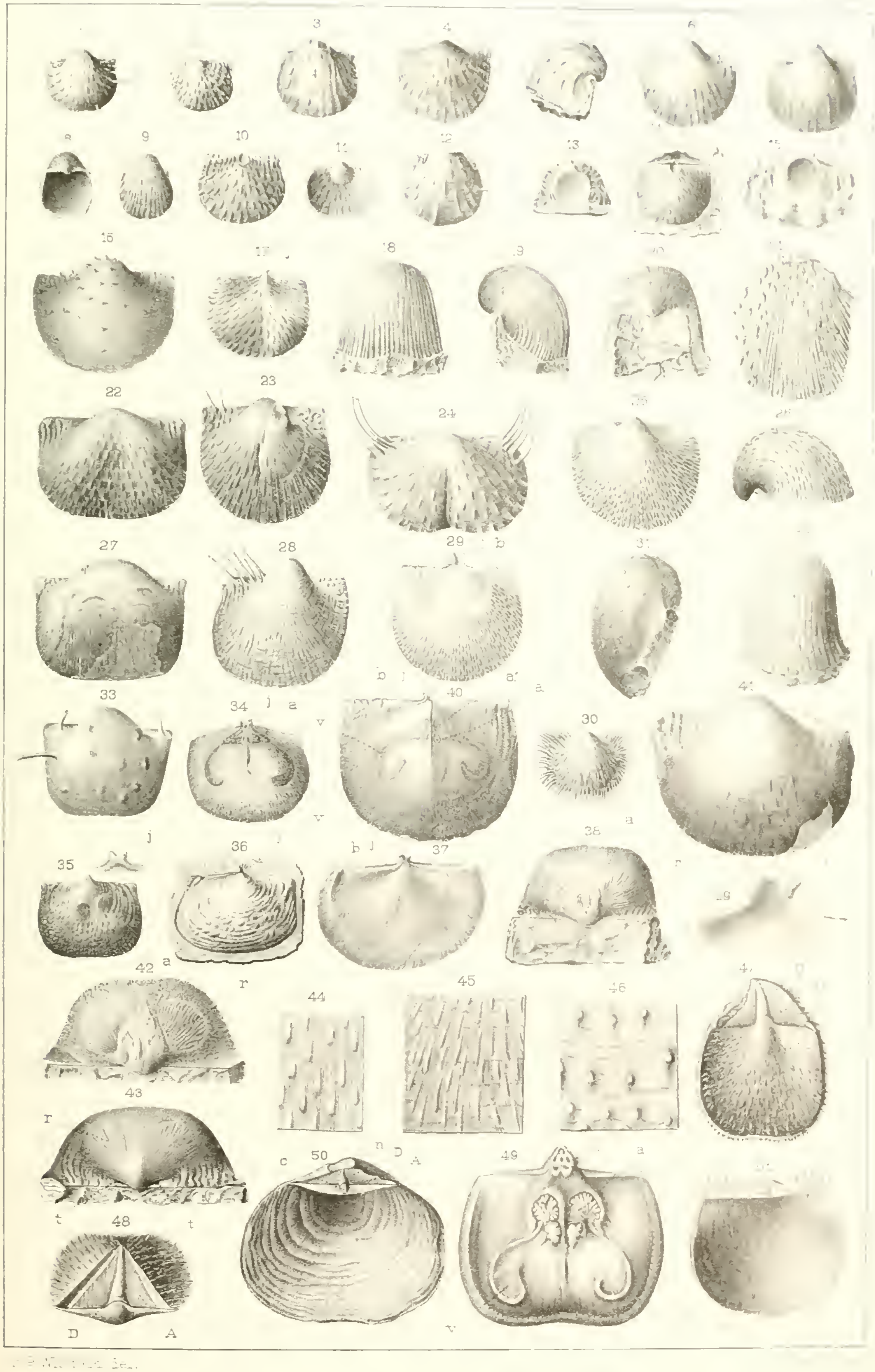
PRODUCTELLA SUBALATA, Hall.

Fig. 16. Exterior of the pedicle-valve; from one of the original specimens.
Hamilton group. *Rock Island, Illinois.*



PRODUCTELLA EXANTHEMATA, Hall.

Fig. 17. The interior of a brachial valve; showing the cardinal process.
Hamilton group. *Tinker's Falls, N. Y.*

PRODUCTELLA COSTATULA, Hall.

Figs. 18, 19, 20. Three views of a pedicle-valve.
Chemung group. *Chemung county, N. Y.*

Fig. 35. The interior of a brachial valve. Above the figure is an enlargement of the cardinal process.
Chemung group. *Cattaraugus county, N. Y.*

PRODUCTELLA DUMOSA, Hall.

Fig. 21. The exterior of a pedicle-valve, showing the rounded costæ with numerous spine-bases.
Hamilton group. *Canandaigua lake, N. Y.*

PRODUCTELLA LACHRYMOSA, Conrad, var. LIMA, Conrad.

Fig. 22. A view of the pedicle-valve.

Fig. 23. A pedicle-valve with somewhat more elliptical outline.
Chemung group. *Cattaraugus county, N. Y.*

PRODUCTELLA BOYDI, Hall.

Fig. 24. A pedicle-valve retaining the spines on the cardinal extremities.
Chemung group. *Near (Philipsburgh) Belmont, N. Y.*

PRODUCTELLA SPECIOSA, Hall.

Figs. 25, 26. Two views of the pedicle-valve; showing the closely-arranged spine-bases.
Chemung group. *Chautauqua county, N. Y.*

PRODUCTELLA STRIATULA, Hall.

Fig. 27. The exterior of a pedicle-valve.

Fig. 38. Cardinal view of an internal cast of the pedicle-valve; showing the muscular scars.

Fig. 44. An enlargement of the external surface of the shell.
Chemung group. *Chautauqua county, N. Y.*

PRODUCTELLA HIRSUTA, Hall.

Fig. 28. A pedicle-valve, retaining spines near the cardinal margin.

Fig. 39. An enlargement of the cardinal process; showing the divergence of the lobes and the edge of the grooves on their posterior face.

Fig. 45. An enlargement of the external surface.
Chemung group. *Meadville, Pennsylvania.*

PRODUCTELLA HYSTRICULA, Hall.

Fig 29. The interior of the brachial valve; showing the cardinal process and the dental sockets. × 2.

Fig. 30. The exterior of the pedicle-valve; showing the fine, closely crowded spines.
Chemung group. *Chatauqua county, N. Y.*

PRODUCTELLA ARCUATA, Hall.

Figs. 31, 32. Two views of a pedicle-valve.
Yellow sandstones. *Burlington, Iowa.*

PRODUCTELLA RARISPINA, Hall.

Fig. 33. A pedicle-valve with a few scattered spines.
Chemung group. *Alleghany county, N. Y.*

PLATE XVII—Continued.

PRODUCTELLA PYXIDATA, Hall.

Fig. 34. The interior of a brachial valve; showing the cardinal process, muscular scars and brachial ridges.
Choteau limestone. *Pike county, Missouri.*

PRODUCTELLA ARCTIROSTRATA, Hall.

Fig. 36. The impression of the exterior of a brachial valve; showing that the cardinal process is quadrilobate on its posterior face.
Chemung group. *Cattaraugus county, N. Y.*

PRODUCTELLA HIRSUTA, var. RECTISPINA, Hall.

Fig. 37. The interior of a brachial valve; showing the cardinal process and slightly developed crural plates.
Chemung group. *Steuben county, N. Y.*

PRODUCTELLA ONUSTA, Hall.

Fig. 40. The interior of a brachial valve; showing cardinal process, dental sockets, muscular and brachial impressions.

Fig. 41. An exfoliated exterior of the pedicle-valve.
Chemung group. *Cattaraugus county, N. Y.*

Figs. 42, 43. Cardinal views of internal casts of the pedicle-valve; showing the muscular scars.
Chemung group. *Conewango, N. Y.*

Fig. 46. An enlargement of the surface.

GENUS AULOSTEGES, VON HELMERSEN.

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AULOSTEGES WANGENHEIMI, de Verneuil.

Figs. 47, 48. Two views of a specimen; showing the highly developed cardinal area and deltidium.

Fig. 49. The interior of a brachial valve. (After DAVIDSON.)
Permian. *Russia.*

GENUS STROPHALOSIA, KING.

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STROPHALOSIA GERARDI, King.

Fig. 50. View of the shell; showing the lamellose brachial valve, cardinal areas, deltidia and the umbonal cicatrix. (After DAVIDSON.)
Permian. (?) *Spiti, India.*

GENUS PRODUCTELLA, HALL.

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PRODUCTELLA PRODUCTOIDES, Murchison.

Fig. 51. View from the brachial valve; showing the cardinal area and deltidia, and the marginal spines of the pedicle-valve. (After DAVIDSON.)
Upper Devonian. *North Devon, England.*

PLATE XVIIA.

(Figures 1-5, 8, 9, 11, 12, 14, 21, 25, 26 by E. EMMONS; 6, 7, 10, 13, 15-20, 22-24 by G. B. SIMPSON.)

Legend. A. Cardinal area (pedicle-valve).
D. Deltidium (pedicle-valve).
C. Deltidium (brachial valve).
j. Cardinal process.
t. Teeth.
x. Scar of attachment.
z. Posterior ridge limiting internal cavity.
a. Anterior adductor scars.
a′. Posterior adductor scars.
r. Diductor scars.

GENUS STROPHALOSIA, KING.

(See Plates XVB and XVII.)
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STROPHALOSIA ROCKFORDENSIS, sp. nov.

Fig. 1. A view of an imperfect specimen which retains the cardinal area and deltidium of each valve. × 2.

Fig. 2. Cardinal view of the same specimen; showing the scar of attachment. × 2.

Upper Devonian. *Rockford, Iowa.*

STROPHALOSIA CYMBULA, sp. nov.

Figs 3, 4. Opposite sides of the same specimen; showing the cardinal areas, deltidia and scar of attachment.

Keokuk group. *Lebanon, Kentucky.*

Figs. 8, 9. Opposite sides of a larger individual, which is somewhat crushed at the apex of the brachial valve.

Keokuk group. *South of Louisville, Kentucky.*

STROPHALOSIA KEOKUK, Beecher.

Fig. 5. A small individual; showing the great length of the spines.

Fig. 6. An attached specimen; showing deltidia, cardinal areas and adherent spines. × 2.

Fig. 7. The cardinal portion of the same specimen enlarged to show the prolongation of the deltidium into a tube or sheath for the pedicle. × 4.

Keokuk group. *Crawfordsville, Indiana.*

GENUS PRODUCTELLA, HALL.

(See Plate XVII.)
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PRODUCTELLA, sp. (?)

Fig. 10. Cardinal view of an undetermined species, which retains the cardinal areas and deltidia of both valves and the marginal spines of the pedicle-valve. × 2.

Chemung group. *Greenwood, N. Y.*

PRODUCTELLA PYXIDATA, Hall.

(See Plate XVII, fig. 34.)

Fig. 14. The cardinal portion of the pedicle-valve; showing the area and teeth. × 2.

Choteau limestone. *Pike county, Missouri.*

GENUS PRODUCTUS, SOWERBY.

(See Plates XVIII and XIX.)
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PRODUCTUS (MARGINIFERA ? ?) DISSIMILIS, Hall (= *Productella Hallana*, Walcott).

Fig. 11. The interior of a pedicle-valve; showing the sharp, papillose ridges or platforms diverging from the umbo. × 2.

Fig. 12. The interior of a brachial valve which shows corresponding pitted ridges diverging from the bases of the cardinal process. This specimen also shows the remarkably extended brachial areas. × 2.

Upper Devonian. *Lime Creek, Iowa.*

Productus (Marginifera) Lasallensis, Worthen.

Fig. 13. The interior of a brachial valve; showing the character of the internal ridge (*z*), distinguishing the sub-genus Marginifera. In this species probably occurs the most extreme development of this feature among the American productids. × 2.

Upper Carboniferous. *La Salle, Illinois.*

Productus magnus, Meek and Worthen.

Fig. 15. A much flattened pedicle-valve; showing the original length of the spines about the margins.

Keokuk group. *Crawfordsville, Indiana.*

Productus semireticulatus, Martin.

Fig. 16. A portion of the interior of a brachial valve enlarged to show the structure of the brachial ridges, × 3.

Upper Carboniferous. *Perry county, Ohio.*

Fig. 17. Cardinal view of an internal cast of the pedicle-valve; showing the impressions of the cardinal area, the posterior and anterior adductor and the diductor muscles.

Fig. 18. The interior of a brachial valve, drawn from a gutta-percha impression of an internal cast; showing the muscular scars and the peculiar structure of the brachial areas.

Coal Measures. *Newcastle, Ohio.*

Productus symmetricus, McChesney.

Fig. 19. Posterior view of the cardinal process; showing its great elevation and strongly tripartite division, the middle lobe being produced by the coalescence of the inner members of the two principal divisions of the process. × 3.

Fig. 20. A portion of the brachial valve enlarged to show the structure of the brachial ridges or areas. The surface within the curved ridges is covered with irregular clusters of fine granules, which become more widely scattered in the central region about the median septum. The origin of this structure, as well as that seen in figures 16 and 18, has not been ascertained. × 2.

Upper Coal Measures. *Near Kansas City, Missouri.*

Productus punctatus, Martin.

(See Plate XIX, figs. 14–16.)

Fig. 21. The interior of a brachial valve of a very large and finely preserved specimen. The cardinal process shows the coalescence of the inner apophyses, the deep median groove on its surface indicating the original division into two lobes. The muscular impressions are thickened, strongly arborescent, and show a faint division into anterior and posterior scars. Though so well preserved, the specimen bears no trace of the brachial ridges.

Upper Coal Measures. *Near Kansas City, Missouri.*

Productus æquicostatus, Shumard.

Figs. 22, 23. Two views of a specimen from which the upper or visceral portion of the pedicle-valve is broken, exposing the flattened surface of the lower valve. These figures are introduced to show the peculiar mode of growth of the shell on the anterior margin, a tendency frequently exhibited by the *Striati*, and which, in its extreme development, results in an enfolded expansion or complete tube, as in *P. proboscideus* (Proboscidella).

Coal Measures. *Nebraska.*

Productus (? auriculatus, Swallow.)

Fig. 24. The exterior of a pedicle-valve, the surface of which is free of spines except along the cardinal margin.

Coal Measures. *Near Kansas City, Missouri.*

Genus STROPHALOSIA, King.

Strophalosia spondyliformis, White and St. John.

Figs. 25, 26. Opposite sides of a specimen; showing the cardinal areas, deltidia and scar of attachment.

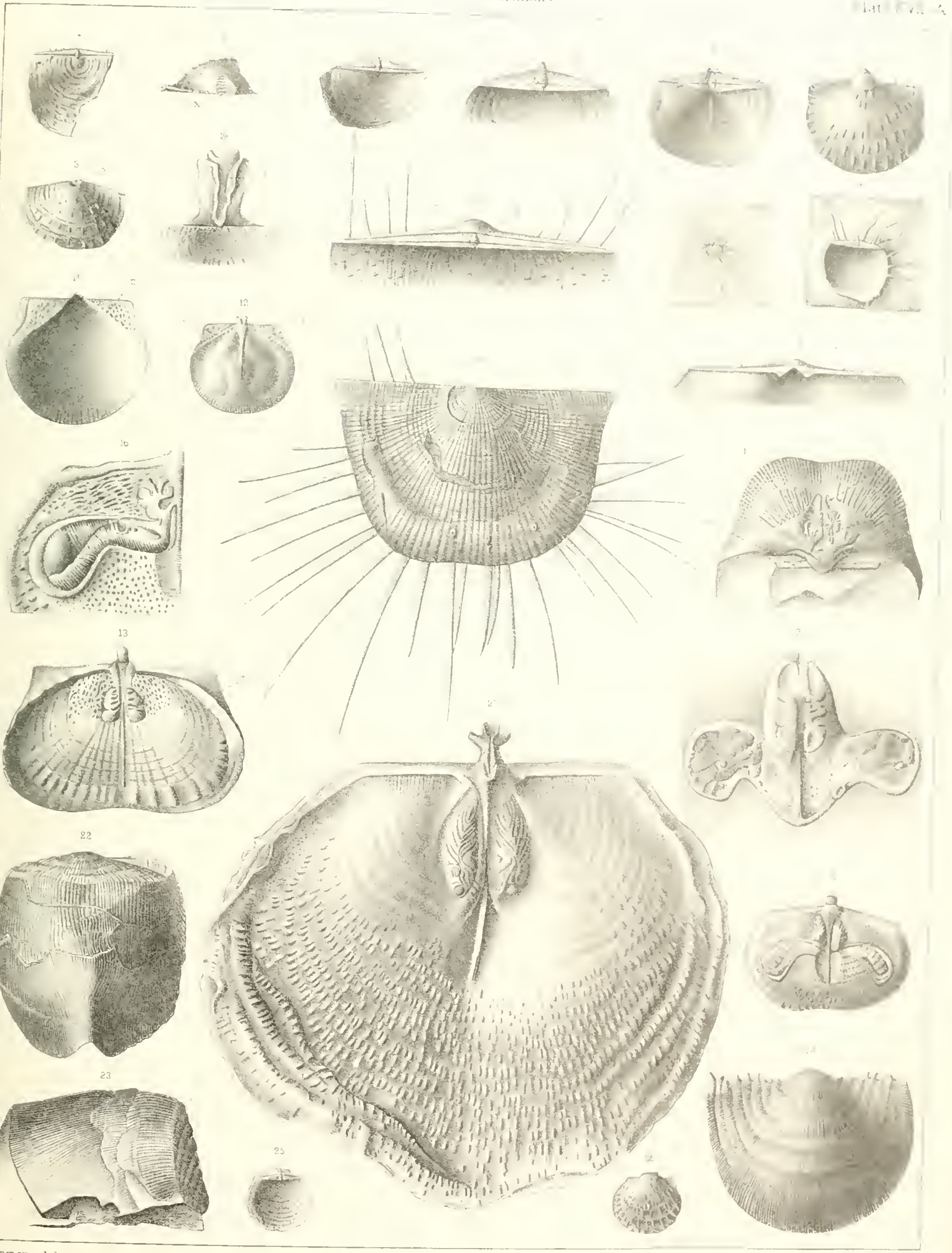
Coal Measures. *Missouri.*

BRACHIOPODA.

Productidæ.

Palæont. N. Y. vol. IV. Pt. II = Vol. VIII.

Generic Illustrations



E. Emmons del.

PLATE XVIII.

(Figures 1-5, 11-17, 19 by R. P. WHITFIELD; 6-13, 18 by F. B. MEEK.)

Legend. j. Cardinal process. a. Anterior adductors.
s. Septum. a′. Posterior adductors.
v. Brachial ridges. r. Diductors.

GENUS PRODUCTUS, SOWERBY.

(See Plates XVIIA, and XIX.)

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PRODUCTUS NEWBERRYI, Hall.

Fig. 1. The exterior of a pedicle-valve; showing the numerous spine-bases and retaining the spines at the cardinal extremities.

Waverly sandstone. *Medina, Ohio.*

Fig. 2. An internal cast of the united valves; showing the muscular impressions of the brachial valve and the brachial ridges.

Fig. 3. An internal cast of a pedicle-valve; showing the adductor and diductor impressions.

Waverly sandstone. *Newark, Ohio.*

PRODUCTUS, sp.? compare PRATTENANUS, Norwood.

Fig. 4. An undetermined pedicle-valve belonging to the group of the *Striati.*

Waverly sandstone. *Newark, Ohio.*

PRODUCTUS, ? sp. ?

Fig. 5. Profile of a pedicle-valve, with spiniferous costæ.

Chemung group. *Cattaraugus county, N. Y.*

PRODUCTUS FLEMINGI, Sowerby, var. BURLINGTONENSIS, Hall.

Figs. 6, 7, 8. Three views of a pedicle-valve.

Burlington limestone. *Burlington, Iowa.*

PRODUCTUS MESIALIS, Hall.

Figs. 9, 10. Two views of a pedicle-valve.

Keokuk group. *Nauvoo, Illinois.*

PRODUCTUS SEMIRETICULATUS, Martin.

Fig. 11. A cast of the exterior of a large brachial valve; showing the surface characters.

Fig. 12. A cardinal view of the pedicle-valve.

Fig. 13. A view of a specimen having the valves united and retaining some of the cardinal spines on the pedicle-valve.

Keokuk group. *Warsaw, Illinois.*

PRODUCTUS ALTERNATUS, Norwood and Pratten.

Fig. 14. A pedicle-valve with the peculiar surface markings, which are due to the exfoliation of the spine-bases.

Keokuk group. *Illinois.*

PLATE XVIII—Continued.

Productus vittatus, Hall.

Fig. 15. A pedicle-valve with a somewhat exfoliated surface, but retaining the concentric growth-lines.

Fig. 16. The interior of the brachial valve; showing the muscular impressions and the cardinal process, bifid on its upper surface.

Fig. 17. The posterior face of the cardinal process of the valve represented in fig. 16; showing a three-fold lobation. × 3

Keokuk group. *Near Keokuk, Iowa.*

Productus tenuicostatus, Hall.

Fig. 18. A profile view; showing the fine surface striation and the expanded anterior margins.

St. Louis limestone. *Milan, Illinois.*

Productus ovatus, Hall.

Fig. 19. A profile; showing the extremely produced anterior margin.

Keokuk limestone. *New Providence, Indiana.*

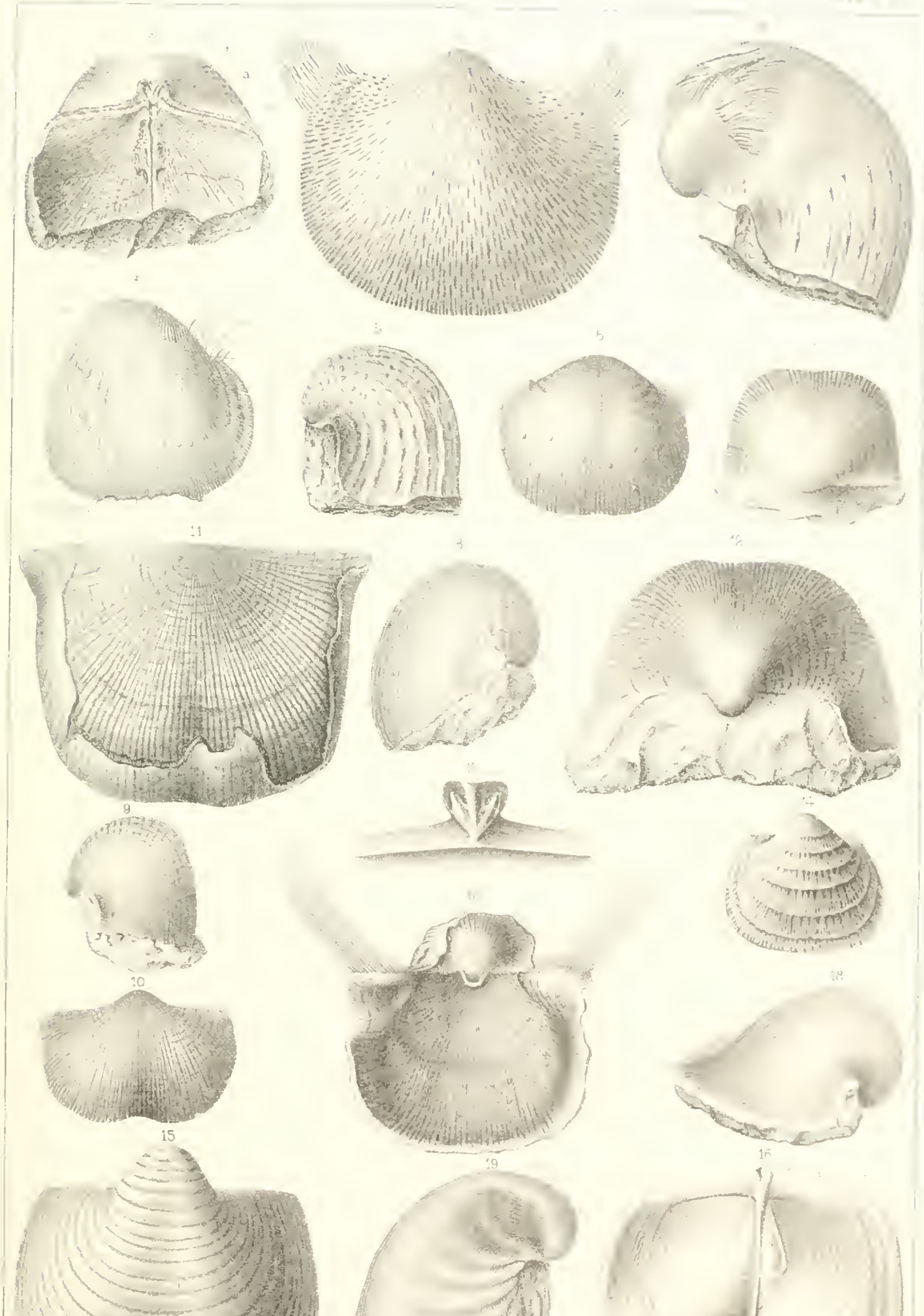

PLATE XIX.

(Figures 1-23 by R. P. WHITFIELD.)

Legend. j. Cardinal process. a′. Posterior adductors.
a (= g). Anterior adductors. v. Brachial ridges.

GENUS PRODUCTUS, SOWERBY.

(See Plates XVIIA and XVIII.)

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PRODUCTUS (MARGINIFERA) SPLENDENS, Norwood and Pratten (*P. longispinus*, Sowerby).

Figs. 1, 2, 3. Three views of a specimen with a few ribs and scattered spine-bases, and a nacreous shell texture.

Upper Coal Measures. *Winterset, Iowa.*

Fig. 4. The interior of a brachial valve; showing the cardinal process, muscular impressions and brachial ridges. At *xx* is a row of short spinules which project from the inner surface of the shell, a feature more highly developed here than in any other species observed. The submarginal ridges which characterize WAAGEN's subgenus MARGINIFERA are not highly developed in this specimen. × 2.

Coal Measures. *La Salle, Illinois.*

PRODUCTUS NEBRASCENSIS, Owen (= *P. aspersus*, McChesney).

Figs. 5, 6, 7. Three views of a specimen; showing the great abundance of short spines.

Coal Measures. *La Salle, Illinois.*

PRODUCTUS COSTATUS, Sowerby.

Fig. 8. The exterior of a pedicle-valve; showing the general character of the specimens referred to this species in this country.

Figs. 9, 10. Profiles of two individuals of different size.

Fig. 11. The interior of a brachial valve, with the muscular impressions and brachial ridges.

Fig. 12. An enlargement of the posterior face of the cardinal process; showing its thickened base and trilobate character. × 3.

Fig. 13. An internal cast of the pedicle-valve; showing the diductor and adductor muscular scars.

Coal Measures. *Winterset, Iowa.*

PRODUCTUS PUNCTATUS, Martin.

Fig. 14. The interior of a brachial valve.

Fig. 15. The cardinal process of the same specimen, viewed from the posterior side. × 3.

Fig. 16. The same in profile. × 3.

Coal Measures. *Missouri.*

Figs. 17, 18. Two views of a pedicle-valve; showing the spiniferous bands which form concentric annulations. Referred to this species with doubt.

Coal Measures. *Locality?*

PRODUCTUS SEMIRETICULATUS, Martin.

Fig. 19. The central portion of a brachial valve, which retains with unusual distinctness the muscular and brachial impressions.

Fig. 20. Posterior view of the cardinal process; showing the complete coalescence of the inner divisions of the two lateral lobes. × 3.

Fig. 21. The inner face of the same. × 3.

Fig. 22. The interior of a small brachial valve.

Fig. 23. The interior of a pedicle-valve; showing the adductor and diductor scars.

Coal Measures. *Itaitubá, Brazil.*

BRACHIOPODA.

Palæont NY Vol IV Pt II

Generic Illustration

Plate

R.P. Whitfield lith.

PLATE XX.

ORTHIS, Dalman.

Page 227.

Orthis flabellites, Hall.

(See Plate V, figs. 37-41.)

Fig. 1. An internal cast of the pedicle-valve ; showing very distinctly the character of the muscular scar, and the simple plication of the surface.

Niagara group. *Hamilton, Ontario.*

Orthis punctostriata, Hall.

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Figs. 2, 3. Two views of a slightly distorted individual, retaining both valves.

Fig. 4. An enlargement of the surface ; showing the rows of superficial punctæ between the striæ.

Niagara group. *Lockport, N. Y.*

Orthis (Rhipidomella) Burlingtonensis, Hall.

(See Plate VIa, fig. 13.)

Fig. 5. An exfoliated pedicle-valve ; showing very distinct impressions of the adductor and diductor scar.

Fig. 6. Posterior view of the cardinal process and crural plates of the brachial valve. × 4.

Chert of the Burlington limestone. *Pike county, Missouri.*

Orthis (Rhipidomella) Michelini, Léveillé.

Fig. 7. The interior of the pedicle-valve ; after Davidson. (British Carboniferous Brachiopoda, pl. xxx, fig. 11.)

Carboniferous limestone. *Ayrshire.*

ORTHOTHETES, Fischer de Waldheim.

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Orthothetes deformis, Hall, var. sinuata, var. nov.

(See Plate IX, fig. 32.)

Figs. 8, 9. Two views of a specimen ; showing the distortion of the beak and the median sinus on the bra-valve, which is a characteristic feature of some species of Derbya. Further examination will probably prove this form to be a distinct species.

Lower Helderberg group. *Cumberland, Md.*

DERBYA, Waagen.

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Derbya Correana, Derby.

(See Plate XI, figs. 18-22.)

Figs. 10, 11. Two views of the umbonal portion of an internal cast of a pedicle-valve, broken to show the filling of the umbonal cavity between the united dental plates. Fig. 10 also shows the impression of the median septum supporting these plates. × 2.

Carboniferous limestone. *Itaitubá, Brazil.*

Derbya crassa, Meek and Hayden.

(See Plates X, XIb, XIc.)

Figs. 12, 13. The interior of both valves of the same specimen ; showing the muscular scars, median septum and cardinal process.

Upper Coal Measures. *Near Kansas City, Missouri.*

ANOPLIA, SUB-GEN. NOV.

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ANOPLIA NUCLEATA, Hall.

(See Plate XVIIA, figs. 17, 18.)

Fig. 14. Internal cast of a pedicle-valve; showing the impression of the short median septum, and the pustulose character of the pallial region. × 3.

Fig. 15. The interior of a brachial valve; showing the muscular impression and the pustulose surface. The cardinal process is bilobed, but is probably shorter than is normal for the species. × 3.

Fig. 16. The exterior of the brachial valve; showing the smooth surface. × 3.

Oriskany sandstone. *Jones county, Illinois.*

Fig. 17. The central cardinal portion of an internal cast of the pedicle-valve; showing the filling of the oblique cardinal tubes which do not penetrate to the external surface. × 6.

Oriskany sandstone. *Columbia county, N. Y.*

CHRISTIANIA, GEN. NOV.

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CHRISTIANIA SUBQUADRATA, Hall.

(See Plates XV and XVIIA.)

Figs. 18, 19. Two views of the pedicle-valve; showing its elongate form, incurvature and smooth or squamous exterior. × 2.

Fig. 20. The exterior of the brachial valve, which shows the cardinal process and edges of the crural plates. × 2.

Lower Helderberg group. *Perry county, Tennessee.*

LEPTÆNA, DALMAN.

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LEPTÆNA RHOMBOIDALIS, Wilckens.

(See Plates VIII and XVIIA.)

Fig. 21. The deltidial area of both valves of a small individual. × 3.

Fig. 21a. Longitudinal section of the two valves; showing the degree of curvature.

Fig. 22. The interior of a brachial valve; showing very distinctly the division into anterior and posterior muscular scars.

Hudson River group. *Cincinnati, Ohio.*

Fig. 23. The interior of a brachial valve, in which the margins of the broad posterior adductors have become elevated into free alate extensions. × 2.

Niagara group. *Waldron, Indiana.*

Fig. 24. The muscular area of the brachial valve, figured on Plate VIII (fig. 31); enlarged from a gutta-percha impression. The area is subdivided into three pairs of scars, the elongate central pair being probably accessory to the posterior adductors. × 3.

Waverly group. *Medina county, Ohio.*

LEPTÆNA ? UNICOSTATA, Meek and Worthen.

See Plate XVIIA, fig. 39.

Figs. 25, 25a. The interior of a brachial valve and cardinal area of a pedicle-valve; showing characters of LEPTÆNA.

Hudson River group. *Ohio.*

STROPHOMENA, RAFINESQUE (DE BLAINVILLE).

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STROPHOMENA WINCHELLI, sp. nov.

(See Plate IX, fig. 12.)

Fig. 26. An enlargement of the muscular area of the brachial valve cited; showing the broad posterior and elongate anterior scars. × 3.

Trenton limestone. *Janesville, Wisconsin.*

BRACHIOPODA.

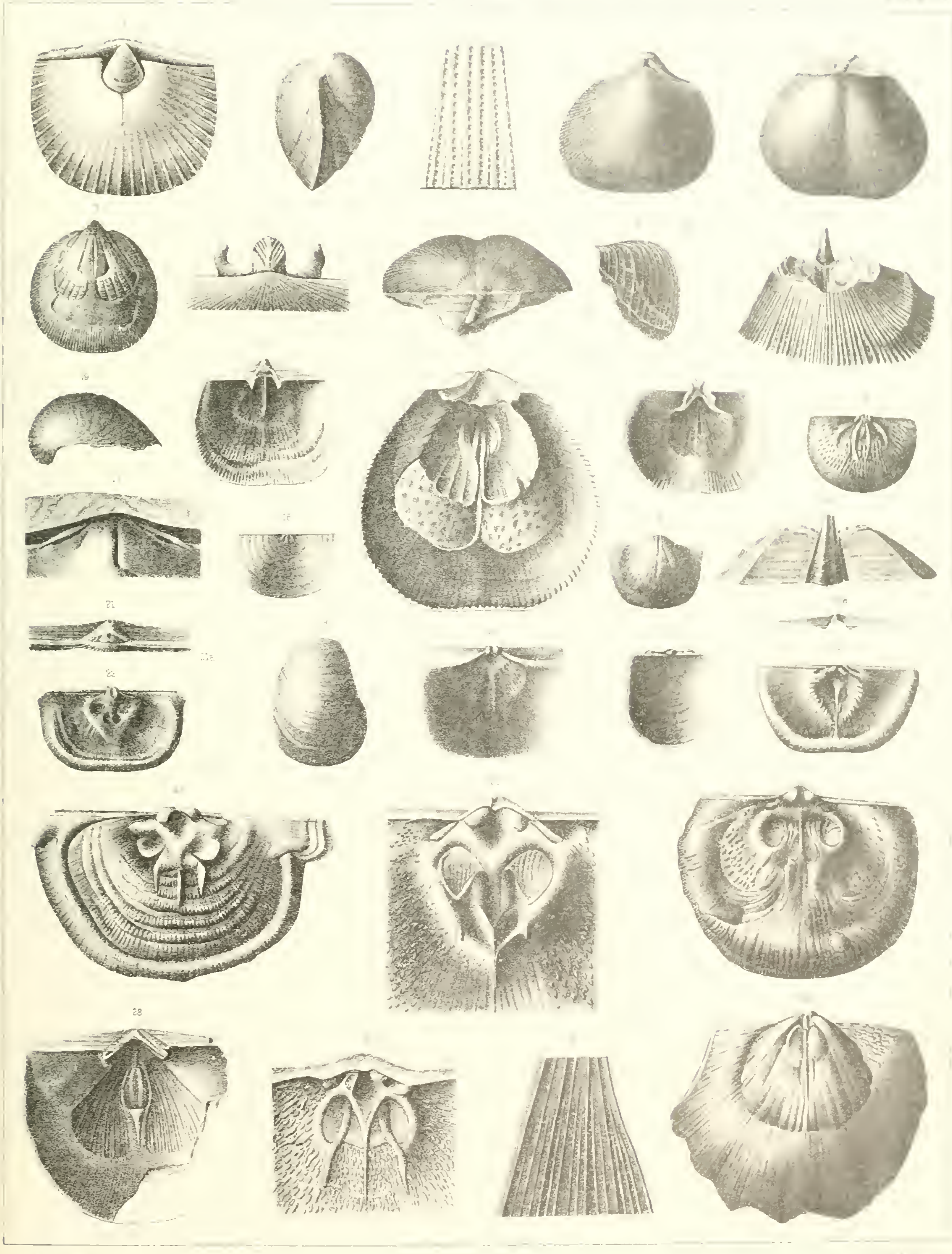

PLATE XX—Continued.

RAFINESQUINA, gen. nov.

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Rafinesquina alternata, Conrad.

(See Plate VIII.)

Fig. 27. The interior of a brachial valve, with sharply defined anterior and posterior adductor scars, and showing faint traces of recurving vascular sinuses.

Fig. 28. The interior of a pedicle-valve, in which the muscular scars have their normal character.

Hudson River group. *Cincinnati, Ohio.*

STROPHEODONTA, Hall.

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Stropheodonta profunda, Hall.

(See Plate XIII, figs. 1–5.)

Fig. 29. An internal cast of the pedicle-valve; showing the broad flabellate diductor scars, meeting in front and enclosing a rather broad pair of adductors.

Fig. 30. An enlargement of the muscular area of the brachial valve. × 1¼.

Fig. 31. The surface striæ. × 2.

Niagara limestone. *Near Milwaukee, Wisconsin.*

STROPHOMENA, Rafinesque (de Blainville).

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Strophomena Conradi, sp. nov.

(See Plate XIa, fig. 3.)

Fig. 32. The profile of a specimen showing only the upper or brachial valve.

Fig 32a. Outline profile of the same specimen.

Trenton limestone. *Trenton Falls, N. Y.*

Fig. 33. Outline profile of figure cited.